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January 29, 2002

Dockets Management Branch
Food and Drug Administration
Department of Health and Human Services
Room 1-23
12420 Parklawn Drive
Rockville, Maryland 20857

Re: Docket 75N-183H Healthcare Continuum Model:
Draft Guideline for Hand Hygiene in Healthcare Settings

Dear Sir or Madam:

A draft guideline for hand hygiene in healthcare settings has recently been prepared by the Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee, the Society for Healthcare Epidemiology of America, the Association for Professionals in Infection Control and Epidemiology, and the Infectious Diseases Society of America. This draft guideline, provided in its entirety in Attachment 1, appeared in the *Federal Register* [66 FR 56680] with comments requested by December 24, 2001.

The Soap and Detergent Association and The Cosmetic, Toiletry, and Fragrance Association (SDA/CTFA) Industry Coalition would like to bring the draft guideline, together with our comments on it (see Attachment 2), to the attention of the Agency in support of the rulemaking for the Final Monograph for OTC Health-Care Antiseptic Drug Products. Part 1 of the guideline provides an independent review of published scientific literature relating to hand hygiene in healthcare settings for many of the active ingredients which are currently included in the Topical Antimicrobial Drug Products for Over the Counter Human Use; Tentative Final Monograph for Health-Care Antiseptic Drug Products [59 FR 31401] and, as such, is an important addition to the Docket.

The Industry Coalition agrees with many of the points that are made in the guideline about the benefits of topical antimicrobial products, specifically:

- We concur that hand washing with plain soap is seldom as complete as washing with a topical antimicrobial product (Tables 1 & 2, pages 33 & 34).

- We concur with the reviewers' finding that, "There is convincing evidence that hand antisepsis can reduce transmission of healthcare-acquired microorganisms" (page 2).

- We concur that many of the active ingredients which are commonly used in topical antibacterial products have an appropriate anti-viral spectrum for use in mitigating the risk of viral disease acquisition (see Appendix, page 47).

Thank you for your consideration of this letter in support of the Final Monograph for topical antimicrobial drug products.

Sincerely,

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Director, Human Health and Safety
The Soap and Detergent Association

Thomas J. Donegan, Jr.
Vice President - Legal & General Counsel
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cc: Charles J. Ganley, M.D. (HFD-560)
Ms. Debbie L. Lumpkins (HFD-560)

Draft Guideline for Hand Hygiene in Healthcare Settings

John M. Boyce, MD; Didier Pittet, MD, MS; the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force; and the Healthcare Infection Control Practices Advisory Committee

Developed and sponsored by the Centers for Disease Control and Prevention (CDC) Healthcare Infection Control Practices Advisory Committee (HICPAC), the Society for Healthcare Epidemiology of America (SHEA), the Association for Professionals in Infection Control and Epidemiology (APIC), and the Infectious Diseases Society of America (IDSA).

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ABSTRACT

Background: Although handwashing has been considered one of the most important measures for reducing transmission of microorganisms in healthcare facilities, adherence of healthcare personnel to recommended handwashing practices is poor.

Objective: Develop evidence-based hand hygiene guideline designed to promote new strategies for improving hand hygiene practices in healthcare facilities and reduce healthcare-acquired infections.

Search strategy for identification of studies: Medline searches of English-language articles published from 1966 through early 2001, review of bibliographies of retrieved articles, and review of abstracts from selected scientific meetings.

Criteria for selecting studies for this review: Articles dealing with handwashing, hand antisepsis, hand hygiene agents, adherence of healthcare personnel to recommended hand hygiene practices, and other aspects of hand hygiene in healthcare facilities were reviewed.

Types of studies: In vitro and in vivo laboratory-based studies, prospective controlled clinical trials, prospective intervention trials, epidemiologic investigations of healthcare-acquired infections, and questionnaire surveys were included.

Outcome measures: Log_{10} reductions in bacterial counts achieved in vitro and in vivo by hand hygiene agents, percent adherence of healthcare personnel to recommended hand hygiene practices, and prevalence and incidence rates of healthcare-acquired infections.

Main results: There is convincing evidence that hand antisepsis can reduce transmission of healthcare-acquired microorganisms. Alcohol-based handrubs reduce bacterial counts on the hands of personnel more effectively than plain or antimicrobial soaps, can be made more accessible than sinks and other handwashing facilities, and require less time to use and cause less skin irritation and dryness than washing hands with soap and water. Long-term multimodal, multidisciplinary programs that address individual and institutional barriers are necessary to achieve enduring improvements in hand hygiene adherence.

Reviewers' conclusions: Promoting increased use of alcohol-based handrubs, when combined with multidisciplinary educational and motivational programs, can lead to improved hand hygiene practices among healthcare personnel. Limited studies suggest that improving adherence to recommended hand hygiene practices can reduce rates of healthcare-acquired infections.

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EXECUTIVE SUMMARY

The "Guideline for Hand Hygiene in Healthcare Settings" provides healthcare practitioners with a thorough review of evidence dealing with handwashing and hand antisepsis in healthcare settings, and specific recommendations to promote improved hand hygiene practices and reduce transmission of pathogenic microorganisms to patients and personnel in healthcare settings.

The present guideline reviews studies published since the 1985 CDC guideline and the 1995 APIC guideline were issued, and provides an in-depth review of hand hygiene practices of healthcare personnel, levels of adherence of personnel to recommended handwashing practices, and factors adversely affecting adherence. New studies of the in vivo efficacy of alcohol-based handrubs and the low incidence of dermatitis associated with their use are reviewed. Recent studies demonstrating the value of multidisciplinary hand hygiene promotion programs and the potential role of alcohol-based handrubs in improving hand hygiene practices are summarized. Recommendations dealing with related issues such as the use of hand lotions or creams and wearing of artificial fingernails are included.

Part I: Review of Scientific Data on Hand Hygiene Practices in Healthcare Settings reviews in detail the efficacy of agents used for handwashing and hand antisepsis and factors adversely affecting adherence of healthcare personnel to recommended hand hygiene practices, including poor access to sinks and handwashing materials, the time required to perform conventional handwashing with soap and water, irritant contact dermatitis associated with frequent exposure to detergents and water, high workloads among personnel, knowledge deficits among care givers regarding when hand contamination occurs and proper hand hygiene techniques, and failure of administrative leaders to make hand hygiene an institutional priority. Using a waterless antiseptic agent such as an alcohol-based handrub minimizes many of the factors adversely affecting adherence to hand hygiene protocols. Alcohol-based handrubs are more effective compared to washing hands with a non-antimicrobial or antimicrobial soap, can be made much more accessible, require less time to use, and are less prone to cause irritant contact dermatitis. Several recent studies suggest that having personnel decontaminate their hands with an alcohol-based handrub between most patient contacts can lead to improved adherence of healthcare workers to hand hygiene policies and reduce infection rates. Part II: Recommendations provides consensus recommendations of the Healthcare Infection Control Practices Advisory Committee (HICPAC) and other professional societies that participated in development of this guideline.

PART I. REVIEW OF THE SCIENTIFIC DATA REGARDING HAND HYGIENE

1. Historical Perspective

For generations, handwashing with soap and water has been considered a measure of personal hygiene.[1] The concept of cleansing hands with an antiseptic agent probably emerged in the early part of the 19th century. As early as 1822, Labarraque, a French pharmacist, demonstrated that solutions containing chlorides of lime or soda could eradicate the foul odors associated with human corpses and that such solutions could be used as disinfectants and antiseptics.[2] In a paper published in 1825, he stated that physicians and others attending patients with contagious diseases would benefit from moistening their hands with liquid chloride solution.[2]

In 1846, Ignaz Semmelweis observed that women whose babies were delivered by students and physicians in the First Clinic at the General Hospital of Vienna consistently had a higher mortality rate than those whose babies were delivered by midwives in the Second Clinic.[3] He noted that physicians who went directly from the autopsy suite to the obstetrics ward had a disagreeable odor on their hands despite washing their hands with soap and water upon entering the obstetrics clinic. He postulated that the puerperal fever that affected so many parturient women was caused by "cadaverous particles" transmitted from the autopsy suite to the obstetrics ward via the hands of students and physicians. Perhaps because of the known deodorizing effect of chlorine compounds, as of May 1847, he insisted that students and physicians clean their hands with a chlorine solution between each patient in the clinic. The maternal mortality rate in the First Clinic subsequently dropped dramatically and remained low for years. This intervention by Semmelweis represents the first evidence suggesting that cleansing heavily contaminated hands with an antiseptic agent between patient contacts may reduce healthcare-acquired transmission of contagious diseases more effectively than handwashing with plain soap and water.

In 1843, Oliver Wendell Holmes concluded independently that puerperal fever was spread by the hands of health personnel.[1] Although he described measures that could be taken to limit its spread, his recommendations had little impact on obstetric practices of the time. However, as a result of the seminal studies by Semmelweis and Holmes, handwashing gradually became accepted as one of the most important measures for preventing transmission of pathogens in healthcare facilities.

In 1961, the U. S. Public Health Service produced a training film that demonstrated handwashing techniques recommended for use by healthcare workers.[4] At the time, it was recommended that personnel wash their hands with soap and water for 1 to 2 min before and after patient contact. Rinsing hands with an antiseptic agent was believed to be less effective than handwashing and was recommended only in emergencies or in areas where sinks were unavailable.

In 1975 and 1985, formal written guidelines on handwashing practices in hospitals were published by the Centers for Disease Control (CDC).[5,6] These guidelines recommended handwashing with non-antimicrobial soap between most patient contacts and washing with antimicrobial soap before and after performing invasive procedures or caring for high-risk patients. Use of waterless antiseptic agents such as alcohol-based solutions was recommended only in situations where sinks were not available.

In 1988 and 1995, guidelines for handwashing and hand antisepsis were published by the Association for Professionals in Infection Control (APIC).[7,8] Recommended indications for handwashing were similar to those listed in the CDC guidelines. The 1995 APIC guideline

included more detailed discussion of alcohol-based waterless antiseptic agents and supported their use in more clinical settings than had been recommended in earlier guidelines. In 1995 and 1996, HICPAC recommended that either antimicrobial soap or a waterless antiseptic agent be used for cleaning hands upon leaving the rooms of patients with multi-drug resistant pathogens such as vancomycin-resistant enterococci (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA).[9,10] These guidelines also included useful recommendations for handwashing and hand antisepsis in other clinical settings, such as those for routine patient care. Although the APIC and HICPAC guidelines have been adopted by most hospitals, adherence of healthcare workers to recommended handwashing practices has remained unacceptably low.[11,12]

Recent developments in the field have stimulated a review of the scientific data regarding hand hygiene and the development of new guidelines designed to improve hand hygiene practices in healthcare facilities. The current literature review and accompanying recommendations have been prepared by a task force comprised of representatives from HICPAC, the Society for Healthcare Epidemiology of America (SHEA), APIC, and the Infectious Diseases Society of America (IDSA).

2. Normal Bacterial Skin Flora

In order to understand the objectives of different approaches to hand cleansing, a knowledge of normal bacterial skin flora is essential. Normal human skin is colonized with bacteria, with total aerobic bacterial counts ranging from more than 1×10^6 CFU/cm^2 on the scalp, 5×10^5 CFU/cm^2 in the axilla and 4×10^4 CFU/cm^2 on the abdomen to 1×10^4 CFU/cm^2 on the forearm.[13] Total bacterial counts on the hands of medical personnel have ranged from 3.9×10^4 to 4.6×10^6.[14-17] In 1938, Price[14] established that bacteria recovered from the hands could be divided into two categories, i.e., transient and resident. Transient flora, which colonize the superficial layers of the skin, are more amenable to removal by routine handwashing. They are often acquired by healthcare workers during direct contact with patients or contaminated environmental surfaces adjacent to the patient, and are the organisms most frequently associated with healthcare-acquired infections. Resident flora, which are attached to deeper layers of the skin, are more resistant to removal. In general, resident flora such as coagulase-negative staphylococci and diphtheroids are less likely to be associated with such infections. The hands of some health personnel may become persistently colonized with pathogenic flora such as *S.aureus*, gram-negative bacilli, or yeast. Price and subsequent investigators documented that although the number of transient and resident flora varies considerably among individuals, it is often relatively constant for any given individual.[14,18]

3. Physiology of Normal Skin

The primary function of the skin is to reduce water loss, provide protection against abrasive action and microorganisms, and generally act as a permeability barrier to the environment. Its basic structure is as follows: the superficial region, termed the stratum corneum or horny layer, is between 10 and 20 μm thick; underlying this region is the viable epidermis (50-100 μm), dermis (1-2 mm), and hypodermis (1-2 mm). The barrier to percutaneous absorption lies within the stratum corneum, the thinnest and smallest compartment. The stratum corneum contains the corneocytes or horny cells, which are flat polyhedral-shaped non-nucleated cells, remnants of the terminally differentiated keratinocytes found in the viable epidermis. Corneocytes are composed primarily of insoluble bundled keratins surrounded by a cell envelope stabilized by cross-linked proteins and covalently bound lipid. Interconnecting the corneocytes of the stratum corneum are polar structures such as corneodesmosomes, which contribute to stratum corneum cohesion.

The intercellular region of the stratum corneum is composed of lipid primarily generated from the exocytosis of lamellar bodies during the terminal differentiation of the keratinocytes. The intercellular lipid is required for a competent skin barrier and forms the only continuous domain. Directly under the stratum corneum is a stratified epidermis, composed primarily of 10-20 layers of keratinizing epithelial cells, which are responsible for the synthesis of the stratum corneum. This layer also contains melanocytes involved in skin pigmentation; Langerhans cells, which are important for antigen presentation and immune responses; and Merkel cells whose precise role in sensory reception has yet to be fully delineated. As keratinocytes undergo terminal differentiation, they begin to flatten out and assume the dimensions characteristic of the corneocytes, i.e., their diameter changes from 10-12 to 20-30 μm and their volume increases by 10 to 20-fold. The viable epidermis does not contain a vascular network, and the keratinocytes obtain their nutrients from below by passive diffusion through the interstitial fluid.

The skin is a dynamic structure. Barrier function does not simply arise from the dying, degeneration, and compaction of the underlying epidermis. Rather, the processes of cornification and desquamation are intimately linked; synthesis of the stratum corneum occurs at the same rate as loss. There is now substantial evidence that the formation of the skin barrier is under homeostatic control. This is illustrated by the epidermal response to barrier perturbation by skin stripping or solvent extraction. There is circumstantial evidence that the rate of keratinocyte proliferation directly influences the integrity of the skin barrier. A general increase in the rate of proliferation will result in a decrease in the time available for (i) uptake of nutrients, such as essential fatty acids; (ii) protein and lipid synthesis; and (iii) processing of the precursor molecules required for skin barrier function. It remains unclear if chronic but quantitatively smaller increases in rate of epidermal proliferation also lead to changes in skin barrier function. Thus, the extent to which the decreased barrier function caused by irritants is due to an increased epidermal proliferation also remains unclear.

The current understanding of the formation of the stratum corneum has come from studies of the epidermal responses to perturbation of the skin barrier. Experimental manipulations that disrupt the skin barrier include (i) extraction of skin lipids with apolar solvents; (ii) physical stripping of the stratum corneum using adhesive tape; and (iii) chemically induced irritation. All of these experimental manipulations lead to a decreased skin barrier as determined by transepidermal water loss (TEWL). Perhaps the most studied experimental system is the treatment of mouse skin with acetone. This leads to a marked and immediate increase in TEWL, indicating a decrease in skin barrier function. Since acetone treatment selectively removes glycerolipids and sterols from the skin, this suggests that these lipids are necessary though perhaps not sufficient in themselves for a barrier function. Detergents (see below) act similarly as acetone on the intercellular lipid domain. The return to normal barrier function is biphasic: 50-60% of barrier recovery is typically seen by 6 hours but complete normalization of barrier function requires 5-6 days.

4. Definition of Terms

Antimicrobial soap. Soap containing an antiseptic agent.

Antiseptic agent. Antiseptics are antimicrobial substances that are applied to the skin to reduce the number of microbial flora. Examples include alcohols, chlorhexidine, chlorine, hexachlorophene, iodine, para-chloro-meta-xylenol, quaternary ammonium compounds, and triclosan.

Antiseptic handwash. Washing hands with water and soap or other detergents containing an antiseptic agent.

Antiseptic handrub. Applying a waterless antiseptic agent to all surfaces of the hands to reduce the number of microorganisms present.

Decontaminate hands. Reducing bacterial counts on hands by performing antiseptic handrub or antiseptic handwash.

Detergent. Detergents (surfactants) are compounds that possess a cleaning action. They are composed of a hydrophilic part and a lipophilic part and can be divided into four groups: anionic, cationic, amphoteric, and non-ionic detergents. Although products used for handwashing or antiseptic handwash in healthcare settings represent various types of detergents, they are usually referred to as soaps.

Hand antisepsis. Refers to either antiseptic handwash or antiseptic handrub.

Hand hygiene. A general term that applies to either handwashing, antiseptic handwash, antiseptic handrub, or surgical hand antisepsis.

Handwashing. Washing hands with plain (non-antimicrobial) soap and water.

Persistent activity. Antimicrobial activity that persists after the agent has been rinsed off the skin or has dried. This property, which is due to binding of the antiseptic agent to the stratum corneum, is also referred to as *residual activity* or *substantivity*.

Plain soap. Plain soap refers to products that do not contain antimicrobial agents, or contain very low concentrations of antimicrobial agents that are effective solely as preservatives. Plain bar soap is comprised of alkyl carboxylate salts, a form of anionic detergent.

Surgical hand antisepsis. Antiseptic handwash or antiseptic handrub performed preoperatively by surgical personnel to eliminate transient and reduce resident hand flora. Antiseptic detergent preparations often have persistent antimicrobial activity.

Visibly soiled hands. Hands showing visible dirt or visibly contaminated with proteinaceous body substances (e.g., blood, fecal material, urine).

Waterless antiseptic agent. An antiseptic agent that does not require use of exogenous water. After applying such an agent, the individual rubs the hands together until the agent has dried.

Food and Drug Administration (FDA) product categories. The 1994 FDA Tentative Final Monograph for Health-care Antiseptic Drug Products divides products into three categories.[19] *Patient preoperative skin preparations* are products applied to a patient's skin to reduce the number of microorganisms on the skin at the site of anticipated surgery. *Antiseptic handwash* or *healthcare personnel handwash* preparations are fast-acting products designed to reduce the number of transient microorganisms on the hands of healthcare workers. A persistent effect is considered desirable, but not necessary. *Surgical hand scrub* refers to antiseptic-containing preparations that significantly reduce the number of microorganisms on the hands of healthcare personnel and have a persistent effect.

5. Evidence of Transmission of Pathogens on Hands

Transmission of healthcare-acquired pathogens from one patient to another via the hands of healthcare workers requires four elements. One, organisms present on the patient's skin, or that have been shed onto inanimate objects immediately surrounding the patient, must be transferred to the hands of healthcare workers. Two, organisms must be capable of surviving for at least several minutes on the hands of personnel. Three, handwashing or hand antisepsis by the worker must be inadequate or omitted altogether, or the agent used for hand hygiene inappropriate. Four, the contaminated hands of the care giver must come in direct contact with another patient, or with an inanimate object that will come in contact with the patient. Evidence supporting each of these elements is given below.

Healthcare-acquired pathogens can be recovered not only from infected or draining wounds, but also from frequently colonized areas of normal, intact patient skin.[20-31] The perineal or inguinal areas tend to be most heavily colonized, but the axillae, trunk, and upper extremities (including the hands) also are frequently colonized.[23,25,26,28,30-32] The number of organisms such as *S. aureus, Proteus mirabilis, Klebsiella* and *Acinetobacter* spp. present on intact areas of the skin of some patients can vary from 100 to 10^6 /cm^2.[25,29,31,33] Diabetics, patients undergoing dialysis for chronic renal failure, and those with chronic dermatitis are particularly likely to have areas of intact skin that are colonized with *S. aureus*.[34-41] Because nearly 10^6 skin squames containing viable microorganisms are shed daily from normal skin,[42] it is not surprising that patient gowns, bed linen, bedside furniture, and other objects in the immediate environment of the patient become contaminated with patient flora.[30,43-46] Such contamination is particularly likely to be due to staphylococci or enterococci, which are resistant to dessication.

Relatively few data are available regarding the types of patient care activities that result in transmission of patient flora to the hands of personnel.[26,45-51] In the past, attempts have been made to stratify patient care activities into those most likely to cause hand contamination,[52] but such stratification schemes were never validated by quantifying the level of bacterial contamination that occurred. More recently, Casewell and Phillips[48] demonstrated that nurses could contaminate their hands with 100 to 1000 CFU of *Klebsiella* spp. during such "clean" activities as lifting patients, taking the patient's pulse, blood pressure, or oral temperature; or touching the patient's hand, shoulder, or groin. Similarly, Ehrenkranz et al.[25] cultured the hands of nurses who touched the groin of patients heavily colonized with *P. mirabilis*, and found 10 to 600 CFU/ml in glove juice samples from nurses' hands. Recently, Pittet and colleagues[51] studied contamination of healthcare workers' hands during activities that involved direct patient contact, wound care, intravascular catheter care, respiratory tract care, or handling patient secretions. Using agar fingertip impression plates, they found that the number of bacteria recovered from fingertips ranged from 0 to 300 CFU. Direct patient contact and respiratory tract care were most likely to contaminate the fingers of care givers. Gram-negative bacilli accounted for 15% of isolates and *S. aureus* for 11%. Importantly, duration of patient care activity was strongly associated with the intensity of bacterial contamination of healthcare worker hands in this study.

Several other studies have documented that personnel can contaminate their hands with gram-negative bacilli, *S. aureus*, enterococci, or *Clostridium difficile* by performing "clean procedures" or touching intact areas of skin of hospitalized patients.[26,45,46,53] Furthermore, personnel caring for infants with respiratory syncytial virus (RSV) infections have acquired RSV by performing activities such as feeding infants, changing diapers, and playing with the infant.[49] Personnel who had contact only with surfaces contaminated with the infants' secretions also acquired RSV. In the above studies, personnel contaminated their hands with RSV and inoculated their oral or conjunctival mucosa. Other studies also have documented that healthcare workers may contaminate their hands (or gloves) merely by touching inanimate objects in patient

rooms.[46,53,54] Also, laboratory-based studies have documented that touching contaminated surfaces can transfer *S. aureus* or gram-negative bacilli to the fingers.[55] Unfortunately, none of the studies dealing with hand contamination of hospital personnel were designed to determine if the contamination resulted in transmission of pathogens to susceptible patients.

Many other studies have documented contamination of healthcare workers' hands with potential healthcare-acquired pathogens, but did not relate their findings to the specific type of preceding patient contact.[15,17,56-61] For example, in studies conducted before glove use was common among healthcare personnel, Ayliffe et al.[60] found that 15% of nurses working in an isolation unit carried a median of 1×10^4 CFU of *S. aureus* on their hands. Twenty-nine percent of nurses working in a general hospital had *S. aureus* on their hands (median count, 3,800 CFU), while 78% of those working in a hospital for dermatology patients had the organism on their hands (median count, 14.3×10^6 CFU). The same survey revealed that 17% to 30% of nurses carried gram-negative bacilli on their hands (median counts ranged from 3,400 CFU to 38,000 CFU). Daschner[58] found that *S. aureus* could be recovered from the hands of 21% of intensive care unit personnel, and that 21% of physician and 5% of nurse carriers had >1000 CFU of the organism on their hands. Maki[16] found lower levels of colonization on the hands of personnel working in a neurosurgery unit, with an average of 3 CFUs of *S. aureus* and 11 CFUs of gram-negative bacilli. Serial cultures revealed that 100% of healthcare personnel carried gram-negative bacilli at least once, and 64% carried *S. aureus* at least once.

6. Models of Hand Transmission

Several investigators have studied transmission of infectious agents using different experimental models. Ehrenkranz et al.[25] asked nurses to touch a patient's groin for 15 seconds, as though they were taking a femoral pulse. The patient was known to be heavily colonized with gram-negative bacilli. Nurses then cleaned their hands by washing with plain soap and water, or by using an alcohol hand rinse. After cleaning their hands, they touched a piece of urinary catheter material with their fingers, and the catheter segment was cultured. The study revealed that touching intact areas of moist skin of the patient transferred enough organisms to the nurses' hands so that subsequent transmission to catheter material occurred despite handwashing with plain soap and water.

Marples et al.[62] studied transmission of organisms from artificially contaminated "donor" fabrics to clean "recipient" fabrics via hand contact and found that the number of organisms transmitted was greater if the donor fabric or the hands were wet. Overall, only 0.06% of the organisms obtained from the contaminated donor fabric were transferred to recipient fabric via hand contact. Using the same experimental model, Mackintosh et al.[63] found that *S. saprophyticus, P. aeruginosa*, and *Serratia* spp. were transferred in greater numbers than was *Escherichia coli* from a contaminated fabric to a clean one following hand contact. Patrick et al.[64] found that organisms were transferred to various types of surfaces in much larger numbers ($>10^4$) from wet hands than from hands that had been dried carefully.

7. Relation Between Hand Hygiene and Acquisition of Healthcare-Acquired Pathogens

Despite a paucity of appropriate randomized, controlled trials, there is substantial evidence that hand antisepsis reduces the incidence of healthcare-acquired infections.[65,66] In what would be considered an intervention trial using historical controls, Semmelweis[3] demonstrated in 1847 that the mortality rate among mothers delivered in the First Obstetrics Clinic at the General Hospital of Vienna was significantly lower when hospital staff cleaned their hands with an antiseptic agent than when they washed their hands with plain soap and water. In the 1960s, a prospective, controlled trial compared the impact of *no* handwashing versus antiseptic

handwashing on acquistion of *S. aureus* among infants in a hospital nursery.[67] The investigators demonstrated that infants cared for by nurses who did not wash their hands after handling an index infant colonized with *S. aureus* acquired the organism significantly more often, and more rapidly, than did infants cared for by nurses who used hexachlorophene to clean their hands between infant contacts.

Several trials have studied the effect on healthcare-acquired infection rates of handwashing with plain soap and water versus some form of hand antisepsis.[68,69] Maki[68] found that healthcare-acquired infection rates were when antiseptic handwashing was performed by personnel. Massanari and Hierholzer[69] found that antiseptic handwashing was associated with lower healthcare-acquired infection rates in some intensive care units, but not others. Doebbeling et al.[70] compared antiseptic handwashing using a chlorhexidine-containing detergent to a combination regimen that permitted either handwashing with plain soap or use of an alcohol-based hand rinse. Healthcare-acquired infection rates were lower when the chlorhexidine-containing product was in use. However, because relatively little of the alcohol rinse was utilized during periods when the combination regimen was in use, and adherence to policies was higher when chlorhexidine was available, it was difficult to tell whether the hand hygiene regimen used or differences in adherence of personnel was responsible for lower infection rates. Several investigators have found that healthcare-acquired acquisition of MRSA was reduced when the antimicrobial soap used for hygienic handwashing was changed.[71,72]

Casewell and Phillips[48] reported that increased handwashing frequency among hospital staff was associated with a decrease in transmission of *Klebsiella* spp. among patients, but did not quantitate the level of handwashing among personnel. More recently, Pittet et al.[73] reported that the frequency of acquisition of various healthcare-acquired pathogens was reduced when hand antisepsis was performed more frequently by hospital personnel. The latter study and another by Larson et al.[74] documented that the prevalence of healthcare-acquired infections decreased as adherence of healthcare workers to recommended hand hygiene measures improved.

In addition to these quasi-experimental studies, outbreak investigations have suggested an association between infections and understaffing or overcrowding that was consistently linked with poor adherence to hand hygiene. During an outbreak, Fridkin[75] investigated risk factors for central venous catheter-associated bloodstream infections. After adjustment for confounding factors, the patient-to-nurse ratio remained an independent risk factor for bloodstream infection, suggesting that nursing staff reduction below a critical threshold may have contributed to this outbreak by jeopardizing adequate catheter care. More recently, Vicca[76] demonstrated the relationship between understaffing and the spread of MRSA in intensive care. These findings tend to show indirectly that an imbalance between workload and staffing leads to relaxed attention to basic control measures, such as hand hygiene, and spread of microorganisms. Harbarth and colleagues[77] investigated an outbreak of *Enterobacter cloacae* in a neonatal intensive care unit, and showed that the daily number of hospitalized children was above the maximal capacity of the unit, resulting in an available space per child well below current recommendations. In parallel, staff on duty was significantly below the number required by the workload, and this also resulted in relaxed attention to basic infection control measures. Adherence to hand hygiene practices before device contact was only 25% during the workload peak, but increased to 70% after the end of the understaffing and overcrowding period. Continuous surveillance showed that being hospitalized during this period carried a 4-fold increased risk of acquiring a healthcare-acquired infection. This study not only shows the association between workload and infections, but highlights also the intermediate step, which is poor adherence to hand hygiene policies.

8. Methods Used to Evaluate the Efficacy of Hand Hygiene Products

8.1 Current methods

Direct comparison of studies of the in vivo efficacy of handwashing, antiseptic handwash, and surgical hand antisepsis protocols is complicated by the fact that methods used by investigators have varied a great deal. Important differences between the various studies include (1) whether hands are purposely contaminated with bacteria before use of test agents, (2) the method used to contaminate fingers or hands, (3) the volume of hand hygiene product applied to the hands, (4) the time the product is in contact with the skin, (5) the method used to recover bacteria from the skin after the test solution has been used, and (6) the method of expressing the efficacy of the product (percent reduction in bacteria recovered from the skin, or log reduction of bacteria released from the skin). Despite these differences, most studies fall into one of two major categories. Studies designed to evaluate products that will be used by healthcare workers for handwashing or antiseptic handwashs between patient contacts are tested for their ability to remove "transient" flora from the hands. A majority of such studies include artificial contamination of the volunteer's skin with a defined inoculum of a test organism before the volunteer uses a plain soap, an antimicrobial soap, or a waterless antiseptic agent. In contrast, products tested for potential use for pre-operative cleansing of surgeons' hands (surgical hand antisepsis protocols) are tested for their ability to remove "resident" flora from the hands, without preceding artificial contamination of the volunteer's hand.

In the United States, antiseptic handwash products intended for use by healthcare personnel are regulated by the FDA's Division of OTC Drug Products. Requirements for in vitro and in vivo testing of healthcare personnel handwash products and surgical hand scrubs are outlined in the FDA Tentative Final Monograph for Healthcare Antiseptic Drug Products.[19] Such products must be evaluated by using a standardized method (E 1174-94) published by the American Society of Testing and Materials.[78] After hands are artificially contaminated with a defined inoculum of a test organism (usually *S. marcescens* or *E. coli*), 5 ml or an amount specified by the manufacturer of the test formulation is applied to the hands, a small amount of tap water is added, hands are completely lathered for 30 sec, and then rinsed with tap water for 30 sec. After washing, test volunteers don rubber gloves, 75 ml of sampling solution is added to each glove, hands are massaged for 1 min, and samples are obtained aseptically for quantitative culture. No neutralizer of the antimicrobial is routinely added to the sampling solution, but if dilution of the antimicrobial in the sampling fluid does not result in demonstrable neutralization, a neutralizer specific for the test formulation is added.

The method most widely used in Europe to evaluate the efficacy of hand hygiene agents is the European Standard 1500 – 1997 (EN 1500- Chemical disinfectants and antiseptics. Hygienic handrub - Test method and requirements).[79] Briefly, this method requires 12 to 15 test volunteers, and a 24-hr growth of broth culture of *E. coli* K12. Hands are washed with a soft soap and dried, then immersed half-way to the metacarpals in the broth culture for 5 sec. Hands are removed, excess fluid is drained off, and hands are dried in the air for 3 min. Bacterial recovery for the initial value is by kneading the fingertips of each hand separately for 60 sec in 10 ml of Tryptic soy broth (TSB) without neutralizers. The hands are removed and disinfected with 3 ml of the handrub agent for 30 sec in a set design. The same operation is repeated with a total disinfection time not exceeding 60 sec. Both hands are rinsed in running water for 5 sec and excess water is drained off. Fingertips of each hand are kneaded separately in 10 ml of TSB with added neutralizers. These broths are used to obtain the final value. Log 10 dilutions of recovery medium are prepared and plated out. Within 3 hours, the same volunteers are tested with the reference disinfectant (60% 2-propanol) and the test product. Colony counts are carried out after 24 and 48 hrs incubation at 36°C. The average colony count of both left and right hand is used for evaluation. The log reduction factor is

calculated and compared with the initial and final values. The reduction factor of the test product should be superior or the same as the reference alcohol-based rub for acceptance. If there is a difference, then the results are analyzed statistically (Wilcoxon test).

Several other methods have been utilized to measure the efficacy of antiseptic agents against a variety of viral pathogens.[80-82]

8.2 Shortcomings of traditional methodologies

Currently accepted methods of evaluating hand hygiene products intended for use by healthcare workers require that test volunteers wash their hands with a plain or antimicrobial soap for 30 sec or 1 min, despite the fact that the average duration of handwashing by hospital personnel has been observed to be less than 15 sec in a majority of studies.[52,83-88] A few investigators have used 15-sec handwashing or hygienic hand wash protocols.[89-93] Therefore, almost no data exist regarding the efficacy of plain or antimicrobial soaps under conditions in which they are actually used by healthcare workers. Similarly, some accepted methods for evaluating waterless antiseptic agents for use as antiseptic handrubs require that 3 ml of alcohol be rubbed into the hands for 30 sec, followed by a repeat application of the same type. This type of protocol also does not reflect actual usage patterns among healthcare personnel. Further studies should be conducted at the bedside using standardized protocols to obtain more realistic views of microbial colonization and risk of bacterial transfer and cross-transmission.[51]

9. Review of Preparations Used for Hand Hygiene

9.1. Plain (non-antimicrobial) soap

Soaps are detergent-based products that contain esterified fatty acids and sodium or potassium hydroxide. They are available in various forms including bar soap, tissue, leaf and liquid preparations. Their cleaning activity is due to their detergent properties, which result in removal of dirt, soil, and various organic substances from the hands. Plain soaps have little if any antimicrobial activity. However, handwashing with plain soap can remove loosely adherent transient flora. For example, handwashing with plain soap and water for 15 sec reduces bacterial counts on the skin by 0.6 to 1.1 $\log_{10}$, whereas washing for 30 sec reduces counts by 1.8 to 2.8 $\log_{10}$.[1] However, in a number of studies, handwashing with plain soap failed to remove pathogens from the hands of hospital personnel.[25,45] Handwashing with plain soap may sometimes result in paradoxical increases in bacterial counts on the skin.[91,94-96] Although non-antimicrobial soaps are often assumed to have low irritancy potential because they do not contain antiseptics, some formulations may be associated with considerable skin irritation and dryness.[91,95,97] Occasionally, plain soaps have become contaminated, which may lead to colonization of hands of personnel with gram-negative bacilli.[98]

9.2. Alcohols

Most alcohol-based hand antiseptics contain either isopropanol, ethanol, n-propanol, or a combination of two of these products. Studies of alcohols have evaluated either individual alcohols in varying concentrations (a majority of studies), combinations of two alcohols, or alcohol solutions containing small amounts of hexachlorophene, quaternary ammonium compounds, povidone-iodine, triclosan, or chlorhexidine gluconate.[60,92,99-118]

The antimicrobial activity of alcohols is due to their ability to denature proteins.[119] Alcohol solutions containing 50% to 80% alcohol are most effective, with higher concentrations being less potent.[120,121] This paradox is due to the fact that proteins are not denatured easily in the

absence of water.[119]

Alcohols have excellent in vitro germicidal activity against gram-positive and gram-negative vegetative bacteria (including multi-drug resistant pathogens such as MRSA and VRE), *Mycobacterium tuberculosis*, and a variety of fungi.[119-127] However, they have very poor activity against bacterial spores. Herpes simplex virus, human immunodeficiency virus (HIV), influenza virus, respiratory syncytial virus, and vaccinia virus are quite susceptible to alcohols.[119,128,129] Other viruses that are somewhat less susceptible, but are killed by 50% to 70% alcohol, include hepatitis B virus, enteroviruses, rotavirus, and adenovirus.[80,119] In general, ethanol has greater activity against viruses than isopropanol.

Numerous studies have documented the *in vivo* antimicrobial activity of alcohols. Early quantitative studies of the effects of antiseptic handrubs established that alcohols effectively reduce bacterial counts on the hands.[14,120,123,130] Typically, log reductions of the release of test bacteria from artificially contaminated hands average 3.5 $\log_{10}$ after a 30-sec application, and 4.0 to 5.0 $\log_{10}$ after a 1-min application.[1] Alcohols are rapidly germicidal when applied to the skin, but have no appreciable persistent (residual) activity. However, regrowth of bacteria on the skin occurs slowly after use of alcohol-based hand antiseptics, presumably because of the sublethal effect alcohols have on some of the skin bacteria.[131,132] Addition of chlorhexidine, quaternary ammonium compounds, octenidine, or triclosan to alcoholic solutions can result in persistent activity.[1]

A few studies have examined the ability of alcohol to prevent the transfer of healthcare-acquired pathogens by using experimental models of pathogen transmission.[25,62,63] Ehrenkranz et al.[25] found that gram-negative bacilli were transferred from a colonized patient's skin to a piece of catheter material via the hands of nurses in only 17% of experiments following antiseptic handrub with an alcohol-based hand rinse. In contrast, transfer of the organisms occurred in 92% of experiments following handwashing with plain soap and water. This experimental model suggests that when the hands of healthcare personnel are heavily contaminated, an antiseptic handrub using an alcohol-based rinse can prevent pathogen transmission more effectively than can handwashing with plain soap and water. Table 1 summarizes a number of studies that have compared alcohol-based products to plain soap or antimicrobial soaps to determine which was more effective for standard handwashing or hand antisepsis by health personnel.[25,53,60,92,105-111,118,133-142] In all studies that included plain soap, alcohols were more effective than plain soap. In all but one of the trials that compared alcohol-based solutions to antimicrobial soaps or detergents, alcohol was superior to washing hands with soaps or detergents containing hexachlorophene, povidone-iodine, 4% chlorhexidine, or triclosan. In studies dealing with antimicrobial-resistant organisms, alcohol-based products reduced the number of multi-drug- resistant pathogens recovered from the hands of healthcare workers more effectively than did handwashing with soap and water.[143-145]

The effectiveness of alcohols for pre-operative cleaning of the hands of surgical personnel has been addressed in numerous studies.[1,100,103,112-118,131,133,137,146-149] In many of these studies, bacterial counts on the hands were determined immediately after using the product and again 1 to 3 hr later. The delayed testing is performed to determine if regrowth of bacteria on the hands is inhibited during operative procedures. The relative efficacy of plain soap, antimicrobial soaps, and alcohol-based solutions to reduce the number of bacteria recovered from hands immediately after use is shown in Table 2. Alcohol-based solutions were more effective than washing hands with plain soap in all studies, and were more effective than antimicrobial soaps or detergents in most experiments.[100,103,112-118,131,133,137,147-149] Table 3 shows the $\log_{10}$ reductions in the release of resident skin flora from clean hands immediately and 3 hr after use of surgical handrub products. Alcohol-based preparations proved more effective than plain soap and water and, with most formulations, were superior to povidone-iodine or chlorhexidine.

The efficacy of alcohol-based hand hygiene products is affected by a number of factors, including the type of alcohol used, the concentration of alcohol, the contact time, the volume of alcohol used, and whether the hands are wet when the alcohol is applied. Small volumes (0.2 – 0.5 ml) of alcohol applied to the hands are not more effective than washing hands with soap and water.[62,63] Larson et al.[90] documented that 1 ml of alcohol was significantly less effective than 3 ml. Because alcohol-impregnated towelettes contain a small amount of alcohol, they are not much more effective than washing with soap and water.[62,150,151]

Alcohol-based waterless antiseptics intended for use in hospitals are available as rinses (with low viscosity), gels, and foams. Few data are available regarding the relative efficacy of various formulations. One small field trial found that an ethanol gel was somewhat more effective than a comparable ethanol solution at reducing bacterial counts on the hands of healthcare workers.[152] However, further studies are warranted to determine the relative efficacy of alcohol-based rinses and gels.

Frequent use of alcohol-based formulations for hand antisepsis tends to cause drying of the skin unless emollients, humectants, or other skin conditioning agents are added to the formulations. For example, the drying effect of alcohol can be reduced or eliminated by adding 1% to 3% glycerol or other skin conditioning agents.[89,92,99,100,105,131,133,153,154] Recently, several prospective trials have demonstrated that alcohol-based rinses or gels containing emollients may cause less skin irritation and dryness than do commonly used detergents.[95,97,155,156] These studies, which were conducted in clinical settings, used a variety of subjective and objective methods for assessing skin irritation and dryness. Importantly, despite the fact that different commercially available products were tested, the alcohol-based handrub in each trial caused significantly less skin irritation and dryness than did washing hands with soap and water.

Even well-tolerated alcohol handrubs containing emollients may cause a transient stinging sensation at the site of any broken skin (cuts, abrasions). Alcohol handrub preparations with strong fragrances may be poorly tolerated by a few healthcare workers with respiratory allergies. Allergic contact dermatitis or contact urticaria syndrome caused by hypersensitivity to alcohol, or to various additives present in some alcohol handrubs, occurs rarely.[157,158] Alcohols are flammable and require that products be stored away from high temperatures or flames. Because alcohols are volatile, containers should be designed so that evaporation is minimized. Contamination of alcohol-based solutions has seldom been reported. One report documented a pseudoepidemic of infections due to contamination of ethyl alcohol by *Bacillus cereus* spores.[159]

9.3. Chlorhexidine

Chlorhexidine gluconate, a cationic bisbiguanide, was developed in England in the early 1950s and introduced into the United States in the 1970s.[8,160] Chlorhexidine base is barely soluble in water, but the digluconate form is water-soluble. The antimicrobial activity of chlorhexidine appears to be attributable to attachment to, and subsequent disruption of cytoplasmic membranes, resulting in precipitation of cellular contents.[1,8] Chlorhexidine's immediate antimicrobial activity is slower than that of alcohols. Chlorhexidine has good activity against gram-positive bacteria, somewhat less activity against gram-negative bacteria and fungi, and minimal activity against tubercle bacilli.[1,8,160] Chlorhexidine is not sporocidal.[1,160] It has in vitro activity against enveloped viruses such as herpes simplex virus, HIV, cytomegalovirus, influenza and respiratory syncytial virus, but significantly less activity against non-enveloped viruses such as rotavirus, adenovirus and enteroviruses.[128,129,161] The antimicrobial activity of chlorhexidine is not seriously affected by the presence or organic material, including blood. Because chlorhexidine is a cationic molecule, its activity can be reduced by natural soaps, various inorganic anions, non-ionic surfactants, and hand creams containing anionic emulsifying agents.[8,160,162] Chlorhexidine gluconate has been incorporated into a number of hand hygiene

preparations. Aqueous or detergent formulations containing 0.5% or 0.75% chlorhexidine are more effective than plain soap, but are less effective than antiseptic detergent preparations containing 4% chlorhexidine gluconate.[131,163] Preparations with 2% chlorhexidine gluconate are slightly less effective than those containing 4% chlorhexidine.[164]

Chlorhexidine has significant residual activity.[105,113-115,117,131,136,163] Addition of low concentrations (0.5 to 1%) of chlorhexidine to alcohol-based preparations results in significantly greater residual activity than alcohol alone.[115,131] When used as recommended, chlorhexidine has an excellent safety record.[160] Little, if any, absorption of the compound occurs through the skin. Care must be taken to avoid contact with the eyes when using preparations with 1% chlorhexidine or greater as the agent can cause conjunctivitis. The frequency of skin irritation is concentration-dependent, with products containing 4% most likely to cause dermatitis when used frequently for antiseptic handwashing.[165] True allergic reactions to chlorhexidine gluconate are very uncommon.[117,160]

9.4. Hexachlorophene

Hexachlorophene is a bisphenol composed of two phenolic groups and 3 chlorine moieties. In the 1950s and early 1960s, emulsions containing 3% hexachlorophene were widely used for hygienic handwashing, as surgical scrubs, and for routine bathing of infants in hospital nurseries. The antimicrobial activity of hexachlorophene is related to its ability to inactivate essential enzyme systems in microorganisms. Hexachlorophene is bacteriostatic, with good activity against *S. aureus*, and relatively weak activity against gram-negative bacteria, fungi, and mycobacteria.[7]

Studies of hexachlorophene as a hygienic handwash and surgical scrub demonstrated only modest efficacy after a single handwash.[53,133,166] Hexachlorophene has residual activity for several hours after use and gradually reduces bacterial counts on hands after multiple uses (cumulative effect).[1,100,166,167] In fact, with repeated use of 3% hexachlorophene preparations, the drug is absorbed through the skin. Infants bathed with hexachlorophene and personnel regularly using a 3% hexachlorophene preparation for handwashing have blood levels of 0.1 to 0.6 ppm hexachlorophene.[168] In the early 1970s, infants bathed with hexachlorophene sometimes developed neurotoxicity (vacuolar degeneration).[169] As a result, in 1972, the Food and Drug Administration warned that hexachlorophene should no longer be used routinely for bathing infants. However, after routine use of hexachlorophene for bathing infants in nurseries was discontinued, a number of investigators noted that the incidence of healthcare-acquired *S. aureus* infections in hospital nurseries increased substantially.[170,171] In several instances, the frequency of infections decreased when hexachlorophene bathing of infants was reinstituted. However, current guidelines recommend against routine bathing of neonates with hexachlorophene because of its potential neurotoxic effects.[172] Hexachlorophene should not be used to bathe patients with burns or extensive areas of abnormal, sensitive skin. Soaps containing 3% hexachlorophene are available by prescription only.[7]

9.5. Iodine and iodophors

Iodine has been recognized as an effective antiseptic since the 1800s. However, because iodine often causes irritation and discoloring of skin, pain when applied to open wounds, and allergic reactions, iodophors have largely replaced iodine as the active ingredient in antiseptics.

Iodine molecules rapidly penetrate the cell wall of microorganisms and inactivate cells by forming complexes with amino acids and unsaturated fatty acids, resulting in impaired protein synthesis and alteration of cell membranes.[173] Iodophors are composed of elemental iodine, iodide or triiodide, and a polymer carrier (complexing agent) of high molecular weight. The

amount of molecular iodine present (so-called "free" iodine), determines the level of antimicrobial activity of iodophors. "Available" iodine refers to the total amount of iodine that can be titrated with sodium thiosulfate.[174] Typical 10% povidone-iodine formulations contain 1% available iodine, and yield free iodine concentrations of 1 ppm.[174] Combining iodine with various polymers increases the solubility of iodine, promotes sustained-release of iodine, and reduces skin irritation. The most common polymers incorporated into iodophors are polyvinyl pyrrolidone (povidone) and ethoxylated nonionic detergents (poloxamers).[173,174] The antimicrobial activity of iodophors also can be affected by pH, temperature, exposure time, concentration of total available iodine, and the amount and type of organic and inorganic compounds present (e.g., alcohols and detergents).

Iodine and iodophors have bactericidal activity against gram-positive, gram-negative, and some spore-forming bacteria and are active against mycobacteria, viruses, and fungi.[8,173,175-178] In vivo studies have demonstrated that iodophors reduce the number of viable organisms that may be recovered from the hands of personnel.[112,135,138,142,145] The extent to which iodophors exhibit persistent antimicrobial activity once they have been washed off the skin is a matter of some controversy. In several studies, persistent activity was found 30 to 60 min after washing hands with an iodophor.[60,116,179] However, in studies where bacterial counts were obtained after individuals wore gloves for 1 to 4 hr after washing, iodophors demonstrated poor persistent activity.[1,103,114,167,180-185] The in vivo antimicrobial activity of iodophors is significantly reduced in the presence of organic substances such as blood or sputum.[8]

Most iodophor preparations used for hand hygiene contain 7.5% to 10% povidone-iodine. However, formulations with lower concentrations also have good antimicrobial activity because dilution tends to increase free iodine concentrations.[186] Iodophors cause less skin irritation and fewer allergic reactions than iodine, but more irritant contact dermatitis than other antiseptics commonly used for hand hygiene.[91] Occasionally, iodophor antiseptics have become contaminated with gram-negative bacilli as a result of poor manufacturing processes and have caused outbreaks or pseudo-outbreaks of infection.[174]

9.6. Para-chloro-meta-xylenol (PCMX)

PCMX is a halogen-substituted phenolic compound that has been used widely as a preservative in cosmetics and other products and as an active agent in antimicrobial soaps. It was developed in Europe in the late 1920's and has been used in the United States since the 1950s.[187]

The antimicrobial activity of PCMX is apparently due to inactivation of bacterial enzymes and alteration of cell walls.[1] It has good in vitro activity against gram-positive organisms and fair activity against gram-negative bacteria, mycobacteria, and some viruses.[1,7,187] PCMX is less active against *P. aeruginosa*, but addition of ethylene-diaminetetraacetic acid (EDTA) increases its activity against *Pseudomonas* spp. and other pathogens.

Relatively few articles dealing with the efficacy of PCMX-containing preparations intended for use by healthcare personnel have been published in the last 25 years, and the results of studies have sometimes been contradictory. For example, in experiments where antiseptics were applied to abdominal skin, Davies et al. found that PCMX had the weakest immediate and residual activity of any of the agents studied.[188] However, when 30-sec hand washes were performed using 0.6% PCMX, 2% chlorhexidine gluconate or 0.3% triclosan, the immediate effect of PCMX was similar to that of the other agents. When used 18 times/day for 5 days, PCMX had less cumulative activity than did chlorhexidine gluconate.[189] When PCMX was used as a surgical scrub, Soulsby et al.[190] reported that 3% PCMX had immediate and residual activity comparable to 4% chlorhexidine gluconate, while two other studies found that the

immediate and residual activity of PCMX was inferior to both chlorhexidine gluconate and povidone-iodine.[164,191] The disparity between published studies may be due in part to the various concentrations of PCMX included in the preparations evaluated, and to other aspects of the formulations tested, including the presence or absence of EDTA.[7,187] Larson concluded that PCMX is not as rapidly active as chlorhexidine gluconate or iodophors, and that its residual activity is less pronounced than that observed with chlorhexidine gluconate.[7,187]

The antimicrobial activity of PCMX is minimally affected by the presence of organic matter, but is neutralized by non-ionic surfactants. Although PCMX is absorbed through the skin, it appears to be safe.[7,187] PCMX is generally well-tolerated, and allergic reactions are relatively uncommon. PCMX is available in concentrations ranging from 0.5% to 3.75%. In-use contamination of a PCMX-containing preparation has been reported.[192]

9.7. Quaternary ammonium compounds

Quaternary ammonium compounds are composed of a nitrogen atom linked directly to four alkyl groups, which may vary considerably in their structure and complexity.[193] Of this large group of compounds, alkyl benzalkonium chlorides have been the most widely used as antiseptics. Other compounds that have been used as antiseptics include benzathonium chloride, cetrimide, and cetylpyridium chloride.[1] The antimicrobial activity of these compounds was first studied in the early 1900s, and a quaternary ammonium compound for pre-operative cleaning of surgeons' hands was used as early as 1935.[193] The antimicrobial activity of this group of compounds appears to be due to adsorption to the cytoplasmic membrane, with subsequent leakage of low molecular weight cytoplasmic constituents.[193]

Quaternary ammonium compounds are primarily bacteriostatic and fungistatic, although they are microbicidal against some organisms at high concentrations.[1] They are more active against gram-positive bacteria than against gram-negative bacilli. Quaternary ammonium compounds have relatively weak activity against mycobacteria and fungi, and have greater activity against lipophilic viruses. Their antimicrobial activity is adversely affected by the presence of organic material, and they are not compatible with anionic detergents.[1,193]

In general, quaternary ammonium compounds are relatively well tolerated. Unfortunately, because of weak activity against gram-negative bacteria, benzalkonium chloride is prone to contamination by these organisms. A number of outbreaks of infection or pseudoinfection have been traced to quaternary ammonium compounds contaminated with gram-negative bacilli.[194-196] For this reason, in the United States, these compounds were seldom used for hand antisepsis during the last 15-20 years. However, newer handwashing products containing benzalkonium chloride or benzathonium chloride have recently been introduced for use by healthcare workers. Further experience with such products is necessary to determine if newer formulations are less prone to contamination.

9.8. Triclosan

Triclosan (chemical name: 2,4,4' –trichloro-2'-hydroxydiphenyl ether) is a nonionic, colorless substance that was developed in the 1960s. It has been incorporated into soaps for use by healthcare personnel and the public, and into a variety of other consumer products. Concentrations ranging from 0.2% to 2% have antimicrobial activity. Triclosan enters bacterial cells and affects the cytoplasmic membrane and synthesis of RNA, fatty acids, and proteins.[197] Recent studies suggest that this agent's antibacterial activity is due in large part to binding to the active site of enoyl-acyl carrier protein reductase.[198,199] The description of a triclosan-resistant bacterial enzyme has raised the question of whether resistance to this agent may develop more readily than to other antiseptic agents. Of additional concern, exposing

Pseudomonas strains containing the MexAB-OprM efflux system to triclosan may select for mutants that are resistant to multiple antibiotics, including fluoroquinolones.[200].

Triclosan has a fairly broad range of antimicrobial activity, but tends to be bacteriostatic.[1] Minimum inhibitory concentrations range from 0.1 to 10 ug/ml, while minimum bactericidal concentrations are 25 to 500 ug/ml. Triclosan's activity against gram-positive organisms (including MRSA) is greater than against gram-negative bacilli, particularly *P. aeruginosa*.[1,197] The agent possesses reasonable activity against mycobacterial and *Candida* spp., but has little activity against filamentous fungi. Triclosan (0.1%) reduces bacterial counts on hands by 2.8 $\log_{10}$ after a one-minute hygienic hand wash.[1] In a number of studies, log reductions achieved have been lower than with chlorhexidine, iodophors, or alcohol-based products.[1,60,139,189,201] Like chlorhexidine, triclosan has persistent activity on the skin. Its activity in handcare products is affected by pH, the presence of surfactants, emollients, or humectants; and the ionic nature of the particular formulation.[1,197] Triclosan's activity is not substantially affected by organic matter, but may be inhibited by sequestration of the agent in micelle structures formed by surfactants present in some formulations. Most formulations containing less than 2% triclosan are well-tolerated and seldom cause allergic reactions. A few reports suggest that providing hospital personnel with a triclosan-containing preparation for hand antisepsis has led to decreased infections caused by MRSA.[71,72] Triclosan's lack of potent activity against gram-negative bacilli has resulted in occasional reports of contaminated triclosan.[202]

9.9. Others agents

More than 100 years after Semmelweis demonstrated the impact of rinsing hands with a hypochlorite solution on maternal mortality related to puerperal fever, Lowbury et al.[203] studied the efficacy of rubbing hands for 30 sec with an aqueous hypochlorite solution. They found that the solution was not more effective than rinsing with distilled water. Rotter[204] subsequently studied the regimen used by Semmelweis, which called for rubbing hands with a 4% [w/w] hypochlorite solution until the hands were slippery (approx. 5 min). He found that the regimen was 30 times more effective than a 1-min rub using 60% isopropanol. However, because hypochlorite solutions tend to be very irritating to the skin when used repeatedly and have a strong odor, they are seldom used for hand hygiene today.

In addition to the antiseptic preparations listed above, products that utilize different concentrations of traditional antiseptics (e.g., low concentrations of iodophor) or contain novel compounds with antiseptic properties are likely to be introduced for use by healthcare personnel. For example, preliminary studies have demonstrated that adding silver-containing polymers to an ethanol carrier (Surfacine) results in a preparation that has persistent antimicrobial activity on animal and human skin.[205] New compounds with good in vitro activity must be tested in vivo to determine their abilities to reduce transient and resident skin flora on the hands of personnel.

9.10. Surgical hand antisepsis

Since the late 1800s, when Lister promoted the application of carbolic acid to the hands of surgeons before procedures, preoperative cleansing of hands and forearms (surgical scrub) with an antiseptic detergent or a waterless antiseptic agent has been an accepted practice.[206] Although there are no randomized controlled trials demonstrating that surgical site infection rates are signficantly lower when preoperative scrubbing is performed with an antiseptic agent rather than a non-antimicrobial soap, a number of factors provide a strong rationale for this practice. There is compelling evidence that bacteria on the hands of surgeons may cause wound infections if introduced into the operative field during surgery.[207] Rapid multiplication of skin bacteria occurs under surgical gloves if hands are washed with a non-antimicrobial soap,

whereas bacterial growth occurs more slowly following preoperative scrubbing with an antiseptic agent.[14,208] Reducing resident skin flora on the hands of the surgical team for the duration of a procedure reduces the risk of bacteria being released into the surgical field if gloves become punctured or torn during surgery.[1,146,209]. Finally, at least one outbreak of surgical site infections occurred when surgeons who normally used an antiseptic surgical scrub preparation switched to a non-antimicrobial product.[210]

Antiseptic preparations intended for use as surgical scrubs are evaluated for their ability to reduce the number of bacteria released from hands (a) immediately after scrubbing, (b) after wearing surgical gloves for one to 6 hrs (persistent activity), and (c) after multiple applications over 5 days (cumulative activity). Immediate and persistent activity are considered the most important. Current guidelines in the United States recommend that agents used for surgical scrubs should significantly reduce microorganisms on intact skin, contain a non-irritating antimicrobial preparation, have broad-spectrum activity, and be fast-acting and/or have a persistent effect.[211]

Numerous studies have demonstrated that formulations containing 50% - 95% alcohol, either alone or combined with small amounts of hexachlorophene or chlorhexidine gluconate, lower bacterial counts on the skin immediately post-scrub more effectively than do other agents (Table 2). The next most active agents (in order of decreasing activity) are chlorhexidine gluconate, iodophors, triclosan, and plain soap.[103,118,166,180,181,183,185,191,212] Because studies of PCMX as a surgical scrub have yielded contradictory results, further studies are needed to establish how the efficacy of this compound compares to that of the above agents.[164,190,191]

Although alcohols are not considered to have persistent antimicrobial activity, bacteria appear to reproduce slowly on the hands after a surgical scrub with alcohol, and bacterial counts on hands after wearing gloves for 1 to 6 hr seldom exceed baseline (pre-scrub) values.[1] Alcohol-based preparations containing 0.5% chlorhexidine gluconate have persistent activity that, in some studies, has equaled or exceeded that of chlorhexidine gluconate-containing detergents.[1,117,131].

Persistent antimicrobial activity of detergent-based surgical scrub formulations is generally greatest for those containing 2% or 4% chlorhexidine gluconate, followed by hexachlorophene, triclosan, and iodophors.[1,101,112-114,149,167,180,181,183-185,212] Because hexachlorophene is absorbed into the blood after repeated use, it is seldom used as a surgical scrub.

For many years, surgical staff frequently scrubbed their hands for 10 min pre-operatively, which frequently led to skin damage. Several studies have demonstrated that scrubbing for 5 min reduces bacterial counts as effectively as a 10-min scrub.[116,213,214] In other studies, scrubbing for 2 or 3 min reduced bacterial counts to acceptable levels.[146,182,184,215,216]

A few studies have suggested that two-stage surgical scrubs utilizing an antiseptic detergent, followed by application of an alcohol-containing preparation, is effective. For example, an initial 1-min or 2-min scrub with 4% chlorhexidine gluconate or povidone-iodine followed by application of an alcohol-based product was as effective as a 5-min scrub with an antiseptic detergent.[113,217]

For many years, preoperative handwashing protocols required personnel to scrub with a brush. However, this practice may damage the skin of personnel and can result in increased shedding of bacteria from the hands.[94,218] Scrubbing with a disposable sponge or combination sponge-brush has been shown to reduce bacterial counts on the hands as effectively as scrubbing with a brush.[219-221] However, several studies suggest that neither a brush nor a sponge is necessary to reduce bacterial counts on the hands of surgical personnel to acceptable levels, especially

when alcohol-based products are used.[101,116,149,155,208,222-224]

9.11. Relative efficacy of plain soap, antiseptic soap/detergent, and alcohols

Comparing studies dealing with the in vivo efficacy of plain soap, antimicrobial soaps, and waterless antiseptic agents is problematic because some studies express efficacy as the percent reduction in bacterial counts achieved, while others give $\log_{10}$ reductions in counts achieved. However, summarizing the relative efficacy of agents tested in each study can provide a useful overview of the *in vivo* activity of various formulations intended for handwashing, hygienic hand wash, antiseptic handrub, or surgical hand antisepsis (see Tables 1-3).

10. Irritant Contact Dermatitis due to Hand Hygiene

10.1 Frequency and pathophysiology of irritant contact dermatitiis

In some surveys, about 25% of nurses have reported symptoms or signs of dermatitis involving their hands, and as many as 85% give a history of having skin problems.[225] Frequent and repeated use of hand hygiene products, particularly soaps and other detergents, is an important cause of chronic irritant contact dermatitis among health personnel.[226] Affected persons often complain of a feeling of dryness or burning, skin that feels "rough", and erythema, scaling, or fissures. Detergents damage the skin by causing denaturation of stratum corneum proteins, changes in intercellular lipids (either depletion or reorganization of lipid moieties), decreased corneocyte cohesion, and decreased stratum corneum water-binding capacity.[226,227] Damage to the skin also changes skin flora, resulting in more frequent colonization by staphylococci and gram-negative bacilli.[17,89] Although alcohols are among the safest antiseptics available, they can cause dryness and irritation of the skin.[1,228] Ethanol tends to be less irritating than n-propanol or isopropanol.[228]

In general, dermatitis is more commonly reported with iodophors.[91] Other antiseptic agents that may cause dermatitis, in order of decreasing frequency, include chlorhexidine, PCMX, triclosan, and alcohol-based products. The irritancy potential of commercially prepared hand hygiene products, which is often determined by measuring transepidermal water loss of persons using the preparation, may be available from the manufacturer. Other factors that may contribute to dermatitis associated with frequent handwashing include using hot water for handwashing, low relative humidity (most common in winter months), failure to use supplementary hand lotion or cream, and perhaps the quality of paper towels.[229,230] Shear forces associated with wearing or removing gloves and allergy to latex proteins may also contribute to dermatitis of the hands of healthcare personnel.

10.2 Proposed methods for reducing adverse effects of agents

Potential strategies for minimizing hand hygiene-related irritant contact dermatitis among healthcare workers include reducing the frequency of exposure to irritating agents (particularly anionic detergents), replacing products with high irritation potential with preparations that cause less damage to the skin, educating personnel about the risks of irritant contact dermatitis, and providing care givers with moisturizing skin care products or barrier creams.[95,97,227,231-233] Reducing the frequency of exposure of healthcare personnel to hand hygiene products would prove difficult, and it is not desirable, given the low levels of adherence to hand hygiene policies in most institutions. Although many hospitals have provided personnel with "mild", non-antimicrobial soaps in hopes of minimizing dermatitis, frequent use of such products may cause greater skin damage, dryness and irritation than some antiseptic preparations.[91,95,97] One

strategy for reducing the exposure of personnel to irritating soaps and detergents is to promote the use of waterless antiseptic agents containing alcohol and various emollients. Several recent prospective, randomized trials have demonstrated that alcohol-based handrubs containing emollients were tolerated better by healthcare personnel than was washing hands with non-antimicrobial soaps or with an antimicrobial soap.[95,97,156] Routinely washing hands with soap and water immediately after using an alcohol handrub may lead to dermatitis. For this reason, personnel should be reminded that it is neither necessary nor recommended to routinely wash hands after each application of an alcohol handrub.

Hand lotions and creams often contain humectants and various fats and oils that can increase skin hydration and replace altered or depleted skin lipids that contribute to the barrier function of normal skin.[227,231] Several controlled trials have shown that regular use (e.g., twice/day) of such products can help prevent (and treat) irritant contact dermatitis caused by hand hygiene products.[232,233] Importantly, in the trial by McCormick et al.,[233] improved skin condition resulting from frequent and scheduled use of an oil-containing lotion led to a 50% increase in handwashing frequency among healthcare workers. The investigators who conducted these trials emphasized the need to educate personnel regarding the value of regular, frequent use of hand-care products.

Recently, barrier creams have been marketed for the prevention of hand hygiene-related irritant contact dermatitis. Such products are absorbed to the superficial layers of the epidermis and are designed to form a protective layer that is not removed by standard handwashing. Of interest, two recent randomized, controlled trials that evaluated skin condition of care givers found that barrier creams did not yield better results that did the control lotion or vehicle utilized.[232,233] As a result, the role of barrier creams in preventing irritant contact dermatitis among healthcare workers remains to be defined.

In addition to evaluating the efficacy and acceptibility of hand-care products, product selection committees should inquire about the potential deleterious effects that oil-containing products may have on the integrity of rubber gloves and on the efficacy of antiseptic agents used in the facility.[8,212]

Factors to Consider When Selecting Hand Hygiene Products

When evaluating hand hygiene products for potential use in healthcare facilities, administrators or product selection committees need to consider numerous factors that can affect the overall efficacy of such products. These include the relative efficacy of antiseptic agents against various pathogens (see Appendix for brief summary), and acceptance of hand hygiene products by personnel.[234,235] Soap products that are not well-accepted by nurses can be an important deterrent to frequent handwashing.[236] Characteristics of a product (either soap or alcohol handrub) that can affect acceptance by personnel include its smell, consistency (feel), and color.[91,237,238] For soaps, ease of lathering also may affect user preference.

Because healthcare workers may wash their hands from a few times per shift to as many as 40 to 50 times per shift, the tendency of products to cause skin irritation and dryness is a major factor that influences acceptance, and ultimate usage, by healthcare personnel.[60,97,234,235,237,239] For example, concern about the drying effects of alcohol was a major cause of poor acceptance of alcohol-based hand hygiene products in hospitals in the United States.[5,133] However, a number of studies have shown that alcohol-based handrubs containing emollients are acceptable to healthcare workers.[89,92,97,99,100,105,133,153,154,156] With alcohol-based products, the time required for drying may also affect user acceptance.

Several studies suggest that the frequency of handwashing or antiseptic handwashing by

personnel is affected by how accessible hand hygiene facilities are.[240-243] In some healthcare facilities, only one sink is available in rooms housing several patients, or sinks are located far away from the door of the room, which may discourage handwashing by personnel leaving the room. In intensive care units, access to sinks may be blocked by bedside equipment such as ventilators or intravenous infusion pumps. In contrast to sinks used for handwashing or antiseptic handwash, dispensers for alcohol-based handrubs do not require plumbing and can be made available adjacent to each patient's bed and at many other locations in patient care areas. Pocket carriage of alcohol-based handrub solutions together with availability of bedside dispensers has been associated with significant improvement in adherence of personnel to hand hygiene protocols.[73,244] In order to avoid any confusion between soap and alcohol handrubs, alcohol handrub dispensers preferably should not be placed adjacent to sinks. Inservice programs for personnel should comment on the fact that washing hands with soap and water after each use of an alcohol handrub is not necessary and is not recommended because it may lead to dermatitis. However, because some personnel feel a "build-up" of emollients on their hands after repeated use of alcohol hand gels, washing hands with soap and water after 5-10 applications of a gel has been recommended by some manufacturers. Automated handwashing machines have been tested by several investigators, usually for the purpose of improving the quality or the frequency of handwashing, but have not been proven to improve hand hygiene practices.[87,245]

Dispenser systems provided by manufacturers or vendors also need to be considered when evaluating hand hygiene products. Dispensers that become blocked or partially blocked and do not deliver the product when accessed by personnel, or do not deliver the product onto the individual's hand appropriately, may discourage use by health personnel. In one recent survey, only 50% of dispensers delivered product onto the care givers' hands with one press of the dispenser lever, and 10% of dispensers were totally occluded (Boyce JM, SHEA Hand Hygiene Workshop, Atlanta). In addition, the volume delivered was often suboptimal, and the product was sometimes squirted onto the wall instead of the care giver's hand.

Little published information is available regarding the cost of hand hygiene products used in healthcare facilities.[155,246] Boyce[246] recently evaluated these costs in patient care areas at a 450-bed community-teaching hospital and found that the hospital spent $22,000 ($0.72 per patient-day) on 2% chlorhexidine-containing preparations, plain soap, and an alcohol hand rinse. When hand hygiene supplies for clinics and non-patient care areas were included, the total annual budget for soaps and hand antiseptic agents was $30,000 (about $1 per patient-day). Annual hand hygiene product budgets at other institutions vary considerably, due to differences in usage patterns and varying product prices. Boyce[246] determined that if non-antimicrobial liquid soap was assigned arbitrarily relative cost of 1.0, the cost per liter was 1.7 times as much for 2% chlorhexidine gluconate detergent, 1.6 to 2.0 times higher for alcohol-based handrub products, and 4.5 times higher for an alcohol-based foam product. A recent cost comparison of surgical scrubbing with an antimicrobial soap versus brushless scrubbing with an alcohol-based handrub revealed that costs and time required for preoperative scrubbing were less with the alcohol-based product.[155] In a trial conducted in two critical care units, Larson et al.[156] found that the cost of using an alcohol handrub was half as much as using an antimicrobial soap for handwashing ($0.025 vs $0.05 per application, respectively).

To put expenditures for hand hygiene products into perspective, healthcare facilities should consider comparing their budget for hand hygiene products to estimated excess hospital costs associated with healthcare-acquired infections. The excess hospital costs associated with only four or five healthcare-acquired infections of average severity may equal the entire annual budget for hand hygiene products used in inpatient care areas. Just one severe surgical site infection, lower respiratory infection, or bloodstream infection may cost the hospital more than the entire annual budget for antiseptic agents used for hand hygiene.[246] Two studies provided

some quantitative estimates of the benefit of hand hygiene promotion programs.[71,73] Webster and colleagues[71] reported a cost saving of approximately $17,000 resulting from reduced use of vancomycin following the observed decrease in MRSA incidence in a 7-month period. Including both direct costs associated with the intervention (increased use of handrub solution and poster reproduction and implementation) and indirect costs associated with healthcare personnel time, Pittet and colleagues[73] estimated the costs of the program to be less than $57,000 per year, an average of $1.42 per patient admitted. Supplementary costs associated with the increased use of alcohol-based handrub solution averaged $6.07 per 100 patient-days. Based on conservative estimates of $2,100 saved per infection averted, and assuming that only 25% of the observed reduction in the infection rate has been associated with improved hand hygiene practice, the program was largely cost-effective. Thus, hospital administrators need to consider the fact if purchasing more effective or more acceptable hand hygiene products improves hand hygiene practices, preventing only a few additional healthcare-acquired infections per year will lead to savings that will exceed any incremental costs of better hand hygiene products.

12. Hand Hygiene Practices Among HCWs

In observational studies conducted in hospitals, healthcare workers washed their hands an average of 5 times per shift to as much as 30 times per shift (Table 4).[17,60,89,97,234,247] Some nurses may wash their hands up to 100 times per shift.[89] Hospital-wide surveillance of hand hygiene revealed that the average number of opportunities varies markedly between hospital wards; for example, nurses in pediatric wards had an average number of 8 opportunities for hand hygiene per hour of patient care compared with an average of 20 for nurses in intensive care units.[11] The duration of handwashing or hygienic hand wash episodes by healthcare personnel has averaged from as low as 6.6 sec to 21 sec in observational studies (Table 5).[17,52,58,83-86,88,225,239] In addition to washing their hands for very short time periods, personnel often fail to cover all surfaces of their hands and fingers.[247]

13. Adherence of healthcare workers to recommended hand hygiene practices

13.1 Observational studies of hand hygiene adherence

Adherence of healthcare workers to recommended hand hygiene procedures has been unacceptably poor, with mean baseline rates ranging from 5% to 81%, with an overall average of about 40% (Table 6).[70,73,80,85,86,236,240,241,243,245,248-271] It should be pointed out that the methods for defining adherence (or non-adherence) and the methods for conducting observations varied considerably among reported studies, and many articles did not include detailed information about the methods and criteria used. Most studies were conducted with hand hygiene adherence as the major outcome measure, while a few measured adherence as part of a broader investigation. A number of investigators reported improved adherence after implementing various interventions, but most studies had short follow-up periods and did not establish if improvements were long-lasting. Studies by Pittet et al.[73] and Larson et al.[74] established that sustained improvements occurred during a long-term program to improve addherence to hand hygiene policies.

13.2 Factors affecting adherence

Factors that may influence hand hygiene include risk factors for non-adherence identified in epidemiologic studies, as well as reasons reported by healthcare workers for lack of adherence to hand hygiene recommendations.

Risk factors for poor adherence to hand hygiene have been determined objectively in several observational studies or interventions to improve adherence.[11,12,234,251,254,272-275] Among these,

being a physician or a nursing assistant, rather than a nurse, was almost consistently associated with reduced adherence. Table 7 lists the major factors identified in observational studies of hand hygiene behavior in the healthcare setting.

In the largest survey conducted so far,[11] the authors identified predictors of poor adherence to recommended hand hygiene measures during routine patient care using a hospital-wide survey. Predictor variables included professional category, hospital ward, time of day/week, and type and intensity of patient care, defined as the number of opportunities for hand hygiene per hour of patient care. In 2,834 observed opportunities for hand hygiene, average adherence was 48%. In multivariate analysis, non-adherence was lowest among nurses compared with other healthcare workers and during weekends (Odds Ratio [OR] 0.6, 95% confidence interval [CI_{95}] 0.4-0.8). It was higher in intensive care units compared with internal medicine (OR 2.0, CI_{95} 1.3-3.1) during procedures that carry a high risk of bacterial contamination (OR 1.8, CI_{95} 1.4-2.4), and when intensity of patient care was high (compared with 0-20 opportunities, 21-40 opportunities, OR 1.3, CI_{95} 1.0-1.7; 41-60 opportunities, OR 2.1, CI_{95} 1.5-2.9; >60 opportunities, OR 2.1, CI_{95} 1.3-3.5). In other words, the higher the demand for hand hygiene, the lower the adherence; on average, adherence decreased by 5% ($\pm$ 2%) for each increase of 10 opportunities per hr when the intensity of patient care exceeded 10 opportunities per hour. Similarly, the lowest adherence rate (36%) was found in intensive care units (ICUs) where indications for hand hygiene were typically more frequent (on average, 20 opportunities per patient-hour). The highest adherence rate (59%) was observed in pediatrics where the average intensity of patient care was lower than elsewhere (on average, 8 opportunities per patient-hour). The results of this study suggest that full adherence to previous guidelines may be unrealistic, and that a facilitated access to hand hygiene could help improve adherence.[11,12,276]

Perceived barriers to adherence with hand hygiene practice recommendations include skin irritation caused by hand hygiene agents, inaccessible hand hygiene supplies, interference with healthcare worker-patient relation, patient needs perceived as a priority over hand hygiene, wearing of gloves, forgetfulness, lack of knowledge of guidelines, insufficient time for hand hygiene, high workload and understaffing, and the lack of scientific information showing a definitive impact of improved hand hygiene on healthcare-acquired infection rates.[11,234,251,254,273-275] Some of the perceived barriers to adherence with hand hygiene guidelines have been assessed, or quantified in observational studies.[12,234,251,254,272-275] Table 7 lists the most frequently reported reasons that are possibly, or effectively, associated with poor adherence. Some of these barriers are discussed below.

Skin irritation by hand hygiene agents constitutes an important barrier to appropriate adherence.[277] Because soaps and detergents can damage skin when applied on a regular basis, healthcare workers need to be better informed about the possible effects of hand hygiene agents. Lack of knowledge and education on this topic is a key barrier to motivation. In particular, it is extremely important to recall that (i) alcohol-based formulations for hand disinfection (whether isopropyl, ethyl, or n-propanol, in 60-90% vol/vol) are less irritating to skin than any antiseptic or nonantiseptic detergents; (ii) alcohols with the addition of appropriate emollients are at least as tolerable and efficacious as detergents; (iii) emollients on healthcare workers' hand skin are recommended and may even be protective against cross-infection by keeping the resident skin flora intact; and (iv) hand lotions help to protect skin and may reduce microbial shedding.[66,232,233]

Easy access to hand hygiene supplies, whether sink, soap, medicated detergent, or waterless alcohol-based handrub solution, is essential for optimal adherence to hand hygiene recommendations. The time required for nurses to leave a patient's bedside, go to a sink, and wash and dry their hands before attending the next patient is a deterrent to frequent handwashing or hand antisepsis.[11,276] Engineering controls could facilitate adherence, but

careful monitoring of hand hygiene behavior should be conducted to exclude the possible negative effect of newly introduced devices.[87]

The impact of wearing gloves on adherence to hand hygiene policies has not been definitively established, since published studies have yielded contradictory results.[86,249,260,278] It is important to recognize that hand hygiene is required regardless of whether gloves are used or changed. Failure to remove gloves after patient contact or between dirty and clean body site care on the same patient has to be regarded as nonadherence to hand hygiene recommendations.[11] Furthermore, Doebbeling and colleagues[279] concluded from their experimental conditions close to clinical practice that it may not be prudent to wash and reuse gloves between patient contact and hand washing or disinfection should be strongly encouraged after glove removal. The authors cultured the organisms used for artificial contamination from 4 to 100% of the gloves and observed counts between 0 and 4.7 log on the hands after glove removal.

Lack of knowledge of guidelines for hand hygiene, lack of recognition of hand hygiene opportunities during patient care, and lack of awareness of the risk of cross-transmission of pathogens are barriers to good hand hygiene practices. Furthermore, some healthcare workers believed that they washed their hands when necessary even when observations indicated they did not.[88,91,254,255,280]

Additional perceived barriers to hand hygiene behavior are listed in Table 7. These are linked not only to the institution but, also, to the healthcare worker's own particular group. Therefore, both institutional and small group dynamics need to be considered when implementing a system change to secure an improvement in healthcare workers' hand hygiene practice.

14. Possible Targets for Hand Hygiene Promotion

Targets for the promotion of hand hygiene are derived from studies assessing risk factors for non-adherence, reported reasons for the lack of adherence to recommendations, and additional factors perceived as important to facilitate appropriate healthcare worker behavior. Although some factors cannot be modified (Table 7), others are definitely amenable to change.

One factor that must be addressed is the time required for healthcare personnel to clean their hands. The results of the large, hospital-wide study on the epidemiology of hand hygiene adherence reported above[11] suggest that time required for traditional handwashing may make full adherence to previous guidelines unrealistic[11,12,276] and that more rapid access to hand hygiene could help improve adherence. One study conducted in an ICU found that it took nurses an average of 62 sec to leave a patient's bedside, walk to a sink, wash their hands, and return to patient care.[276] In contrast, the authors estimated it would require about one fourth as much time to use an alcohol-based handrub placed at each patient's bedside. Providing easy access to hand hygiene materials is mandatory for appropriate hand hygiene behavior, and should be achievable in most healthcare facilities.[281] In particular, in high demand situations (such as in most critical care units), in high stress working conditions, and at times of overcrowding or understaffing, healthcare workers may be more likely to use an alcohol-based handrub than to wash their hands.[281] Further, alcohol-based handrub may be superior to traditional handwashing with plain soap and water or antiseptic hand wash because it not only requires less time,[156,276] but acts faster,[1] irritates hands less often,[1,66,95,97,156] and was used in the only program that reported a sustained improvement in hand hygiene adherence associated with decreased infection rates.[73] However, it must be emphasized that making an alcohol-based handrub available to personnel without ongoing educational and motivational activities may not result in long-lasting improvement in hand hygiene practices.[271] Because increased use of hand hygiene agents might be associated with skin dryness, the availability of free skin care lotion is appropriate and recommended by most experts.

Education is as a cornerstone for improvement with hand hygiene practices. Important topics that must be addressed by educational programs are the lack of scientific information for the definitive impact of improved hand hygiene on healthcare-acquired infection and resistant organism(s) transmission rates, the lack of awareness of guidelines for hand hygiene and insufficient knowledge about indications for hand hygiene during daily patient care, the lack of knowledge about the very low average adherence rate to hand hygiene of most healthcare workers, and the lack of knowledge about the appropriateness, efficacy, and understanding of the use of hand hygiene and skin care protection agents.

Healthcare workers necessarily evolve within a group which functions within an institution. It appears that possible targets for improvement in hand hygiene behavior not only include factors linked to the individual, but also those related to the group(s) and the institution as a whole.[275,281] Examples of possible targets for hand hygiene promotion at the group level include education and performance feedback on hand hygiene adherence, efforts to prevent high workload, downsizing, and understaffing, and encouragement and role model from key staff in the unit. At the institutional level, the lack of written guidelines, available/suitable hand hygiene agents, skin care promotion/agent or hand hygiene facilities, the lack of culture or tradition of adherence as well as the lack of administrative leadership, sanction, rewarding, or support are targets for improvement. Several studies, conducted in different types of institutions, reported modest and even low levels of adherence to recommended hand hygiene practices and showed that it varied by hospital ward and by type of healthcare worker, thus suggesting that targeted educational programs may be useful.[11,248,249,253] Importantly, education should be targeted at individual, group, and institutional levels.[275,281]

15. Lessons from Behavioral Theories

In 1998, Kretzer and Larson[275] revisited the major behavioral theories and their applications with regard to the health professions in an attempt to better understand how to target more successful interventions. They proposed a hypothetical framework to enhance hand hygiene practices and stressed the importance of considering the complexity of individual and institutional factors when designing behavioral interventions.

Behavioral theories and secondary interventions have primarily targeted individuals. But this might be insufficient to effect sustained change.[275,282,283] Interventions aimed at improving hand hygiene practices must consider the various levels of behavior interaction.[12,275,284] Thus, the interdependence of individual factors, environmental constraints, and the institutional climate need to be taken into account in the strategic planning and development of hand hygiene promotion campaigns. Interventions to promote hand hygiene in hospitals should consider variables at all these levels.

The dynamic of behavioral change is complex.[74,281] It involves a combination of education, motivation, and system change. Various factors involved in hand hygiene behavior include intention, attitude towards the behavior, perceived social norm, perceived behavioral control, perceived risk of infection, habits of hand hygiene practices, perceived model role, perceived knowledge, and motivation; they have been discussed in the review by Kretzer and Larson.[275] The factors necessary for change include (i) dissatisfaction with the current situation, (ii) the perception of alternatives, and (iii) the recognition, both at the individual and institutional level, of one's ability and potential to change. While the latter implies education and motivation, the former two necessitate primarily a system change.

Among the reported reasons for poor adherence with hand hygiene recommendations (Table 7), some are clearly related to the institution (i.e., the system) such as the lack of institutional priority for hand hygiene, the lack of administrative sanctions for noncompliers or rewards for

compliers, and the lack of an institutional safety climate. Whereas all three reasons would require a system change in most institutions, the latter would also involve top management commitment, visible safety programs, an acceptable level of work stress, a tolerant and supportive attitude towards reported problems, and the belief in the efficacy of preventive strategies.[12,275,283,285] Importantly, an improvement in infection control practices requires (i) questioning basic beliefs; (ii) continuous assessment of the group (or individual) stage of behavioral change; (iii) intervention(s) with an appropriate process of change; and (iv) supporting individual and group creativity.[275] Because of the complexity of the process of change, it is not surprising that single interventions often fail. Thus, a multimodal, multidisciplinary strategy seems necessary.[73,74,275,281,284]

16. Methods Used to Promote Improved Hand Hygiene

Hand hygiene promotion has been a major challenge for more than 150 years. In-service education, information leaflets, workshops and lectures, automated dispensers, and performance feedback on hand hygiene adherence rates have been associated with, at best, transient improvement.[250,253-255,264,272]

Table 8 reviews published strategies for the promotion of hand hygiene in hospitals and indicates whether the strategies require education, motivation, or system change. Some of the strategies are based on epidemiologic evidence, others on the authors' and other investigators' experience and review of the current knowledge. Some may be unnecessary in certain circumstances, but may be helpful in others. In particular, changing the hand hygiene agent could be beneficial in institutions or hospital wards with a high workload and a high demand for hand hygiene when waterless handrub is not available.[11,72,77,286] However, a change in the recommended hand hygiene agent could be deleterious if introduced during winter, at a time of higher hand skin irritability, and in particular if not accompanied by skin care promotion and protective cream/lotion availability. Specific elements that should be considered for inclusion in educational and motivational programs are listed in Table 9.

Several strategies that could potentially be associated with successful promotion of hand hygiene require a system change (Table 8). Hand hygiene adherence and promotion involve factors at both the individual and system level. Enhancing individual and institutional attitudes regarding the feasibility of making changes (self-efficacy), obtaining active participation of personnel at both levels, and promoting an institutional safety climate, represent major challenges that go well beyond the current perception of the infection control professional's common role.

Whether increased education, individual reinforcement technique, appropriate rewarding, administrative sanction, enhanced self-participation, active involvement of a larger number of organizational leaders, enhanced perception of health threat, self-efficacy, and perceived social pressure,[12,275,287,288] or combinations of these factors would improve healthcare workers' adherence with hand hygiene needs more research. Ultimately, adherence to recommended hand hygiene practices should become part of a culture of patient safety where a set of interdependent elements of quality interact to achieve a shared objective.[289]

Based on the above considerations and successful experiences in some institutions, it appears that strategies to improve adherence to hand hygiene practices should be multimodal and multidisciplinary. It is important to note, however, that the strategies proposed in Table 8 need further research before implementation.

17. Efficacy of Promotion and Impact of Improved Hand Hygiene

The lack of scientific information of the definitive impact of improved hand hygiene on healthcare-acquired infection rates has been reported as a possible barrier to appropriate adherence with hand hygiene recommendations (Table 7). However, members of this Task Force believe that there is convincing evidence that improved hand hygiene can reduce healthcare-acquired infection rates. Failure to perform appropriate hand hygiene is considered the leading cause of healthcare-acquired infections and spread of multi-resistant organisms, and has been recognized as a significant contributor to outbreaks.

Nine quasi-experimental hospital-based studies of the impact of hand hygiene on the risk of healthcare-acquired infections have been published between 1977 and 2000 (Table 10).[48,68-74,255] Despite study limitations, most reports showed a temporal relation between improved hand hygiene practices and reduced infection rates.

In one of these studies, endemic MRSA was eliminated in 7 months in a neonatal ICU following the introduction of a new hand antiseptic.[71] Another study reported an MRSA outbreak involving 22 infants in a neonatal unit.[72] Despite intensive efforts, the outbreak could not be controlled until an antiseptic new to the unit was introduced.

The effectiveness of a longstanding, hospital-wide program to promote hand hygiene at the University of Geneva hospitals has been recently reported.[73] Overall adherence to hand hygiene guidelines during routine patient care was monitored during hospital-wide observational surveys conducted biannually from December 1994 to December 1997, before and during implementation of a hand hygiene campaign, with special emphasis on bedside, alcohol-based hand disinfection. Healthcare-acquired infection rates, attack rates of MRSA cross-transmission, and consumption of handrub disinfectant were measured in parallel. Adherence to recommended hand hygiene practices improved progressively from 48% in 1994 to 66% in 1997 ($p<0.001$). While recourse to handwashing with soap and water remained stable, frequency of hand disinfection markedly increased over the study period ($p<0.001$). This result was unchanged after adjustment for known risk factors of poor adherence. During the same period, both overall healthcare-acquired infection and MRSA transmission rates decreased (both $p<0.05$), and the consumption of alcohol-based handrub solution increased from 3.5 to 15.4 litres per 1000 patient-days between 1993 and 1998 ($p<0.001$). Individual bottles of handrub solution were distributed in large amount to all wards, and custom-made holders were mounted on all beds to facilitate access to hand disinfection. Healthcare workers were also encouraged to carry a bottle in their pocket, and, in 1996, a newly designed flat (instead of round) bottle was made available to further facilitate pocket carriage. The promotional strategy was multimodal and involved a multidisciplinary team of healthcare workers, the use of wall posters, the promotion of bedside, antiseptic handrubs throughout the institution and regular performance feedback to all healthcare workers (see www.hopisafe.ch for further details on methodology). The experience from the University of Geneva hospitals constitutes the first report of a hand hygiene campaign with a sustained improvement over several years, since most experiences in the literature are limited to 6 to 9 months. The multimodal program implemented by Larson et al.[74] also yielded sustained improvements in hand hygiene practices over an extended period.

The beneficial effects of hand hygiene promotion on the risk of cross-transmission also have been reported in surveys conducted in schools or day care centers,[290-295] as well as in a community setting.[296-298] All studies in the literature fail to establish the relative importance of hand hygiene in the prevention of healthcare-acquired infections because they fail to show a causal relationship because of the lack of statistical significance, the presence of confounding factors, or the absence of randomization. Nevertheless, although it remains important to

generate additional scientific and causal evidence for the impact of enhanced adherence with hand hygiene on infection rates, these results indicate that improved hand hygiene practices reduce the risk of transmission of pathogenic microorganisms.

18. Other Policies Related to Hand Hygiene

18.1. Fingernails and Artificial Nails

Numerous studies have documented that subungual areas of the hand harbor high concentrations of bacteria, most frequently coagulase-negative staphylococci, gram-negative rods (including *Pseudomonas* spp.), Corynebacteria, and yeasts.[14,299,300] Freshly applied nail polish does not increase the number of bacteria recovered from periungual skin, but chipped nail polish may support the growth of larger numbers of organisms on fingernails.[301,302] Even after careful handwashing or surgical scrubs, personnel often harbor substantial numbers of potential pathogens in the subungual spaces.[303-305]

Whether artificial nails contribute to transmission of healthcare-acquired infections has been a matter of debate for several years. However, a growing body of evidence suggests that wearing artificial nails may contribute to transmission of certain healthcare-acquired pathogens. Healthcare workers who wear artificial nails are more likely to harbor gram-negative pathogens on their fingertips than are those who have natural nails, both before and after handwashing.[304-306] It is not clear if the length of natural or artificial nails is an important risk factor, since most bacterial growth occurs along the proximal 1 mm of the nail, adjacent to subungal skin.[302,304,305] Recently, an outbreak of *P. aeruginosa* in a neonatal intensive care unit was attributed to two nurses (one with long natural nails and one with long artificial nails) who carried the implicated strains of *Pseudomonas* spp. on their hands.[307] Case patients were significantly more likely than controls to have been cared for by the two nurses during the exposure period, suggesting that colonization of long or artifical nails with *Pseudomonas* spp. may have had a role in causing the outbreak. Personnel wearing artificial nails also have been epidemiologically implicated in several other outbreaks of infection caused by gram-negative bacilli or yeast.[308-310] Although the above reports provide the best evidence to date that wearing artificial nails poses an infection hazard, additional studies of this issue are warranted.

18.2. Gloving policies

For many years, authorities have recommended that healthcare personnel wear gloves for three reasons: to reduce the risk of personnel acquiring infections from patients, to prevent healthcare worker flora from being transmitted to patients, and to reduce transient contamination of the hands of personnel by flora that can be transmitted from one patient to another.[311] Prior to the emergence of the AIDS epidemic, gloves were worn primarily by personnel caring for patients colonized or infected with certain pathogens or by personnel exposed to patients with a high risk of hepatitis B. Since 1987, a dramatic increase in glove use has occurred in an effort to prevent transmission of HIV and other bloodborne pathogens from patients to healthcare workers.[312] The Occupational Safety and Health Administration (OSHA) mandates that gloves be worn during all patient care activities that may involve exposure to blood or body fluids that may be contaminated with blood.[313]

The effectiveness of gloves in preventing contamination of healthcare worker hands has been confirmed in several clinical studies.[45,51,57] One study found that healthcare workers who wore gloves during patient contact contaminated their hands with an average of only 3 CFUs per minute of patient care, compared to 16 CFUs per minute for those not wearing gloves.[51] Two other studies, of personnel caring for patients with *C. difficile* or VRE, found that wearing gloves prevented hand contamination among a majority of those having direct contact with

patients.[45,57] Wearing gloves also prevented personnel from acquiring VRE on their hands when touching contaminated environmental surfaces.[57] Preventing gross contamination of the hands is considered important because handwashing or hand antisepsis may not remove all potential pathogens when hands are heavily contaminated.[25,110]

Several studies provide evidence that wearing gloves can help reduce transmission of pathogens in healthcare settings. In a prospective controlled trial that required personnel to routinely wear vinyl gloves when handling any body substances, the incidence of *C. difficile* diarrhea among patients decreased from 7.7 cases/1000 patient discharges before the intervention to 1.5 cases/1000 discharges during the intervention.[314] The prevalence of asymptomatic *C. difficile* carriage also decreased significantly on "glove" wards, but not on control wards. In intensive care units where VRE or MRSA have been epidemic, requiring all healthcare workers to wear gloves to care for all patients in the unit (universal glove use) appeared to contribute to control of outbreaks.[157,196]

The influence of glove use on hand hygiene habits of personnel is not clear. Several studies found that personnel who wore gloves were *less* likely to wash their hands upon leaving a patient's room.[249,278] In contrast, two other studies found that personnel who wore gloves were significantly *more* likely to wash their hands following patient care.[86,260]

A few caveats regarding use of gloves by healthcare personnel are in order. Personnel should be informed that gloves do not provide complete protection against hand contamination. Bacterial flora colonizing patients may be recovered from the hands of up to 30% of healthcare workers who wear gloves during patient contact.[50,57] Further, wearing gloves does not provide complete protection against acquisition of infections caused by hepatitis B virus and herpes simplex virus.[315,316] In such instances, pathogens presumably gain access to the care giver's hands via small defects in gloves or by contamination of the hands during glove removal.[50,279,315,317]

The integrity of gloves varies considerably based on type of glove material (latex, low-latex, non-latex), the manufacturer, whether gloves are tested before or after use, the intensity of use, and the method used to detect glove leaks.[315,317-322] Vinyl gloves have defects more frequently than do latex gloves, the difference being greatest after use.[315,317,320,323] However, vinyl gloves that are intact provide protection comparable to latex gloves.[315] Limited studies suggest that nitrile gloves have leakage rates that are close to those of latex gloves.[324-327] Although recent studies suggest improvements have been made in the quality of gloves,[322] the laboratory and clinical studies cited above provide strong evidence that hands should be decontaminated or washed after removing gloves.[8,50,57,279,317] Gloves should not be washed or reused.[279,317] Personnel should be reminded that failure to remove gloves between patients may contribute to transmission of organisms.[157,328]

Following use of powderless gloves, some alcohol handrubs may interact with residual powder, resulting in a gritty feeling on the hands. In facilities where powderless gloves are commonly used, a variety of alcohol handrubs should be tested following removal of powdered gloves in order to avoid selecting a product that causes this undesirable reaction.

18.3 Jewelry

Several studies have shown that skin underneath rings is more heavily colonized than comparable areas of skin on fingers without rings.[205,329,330] A study by Hoffman et al.[205] found that 40% of nurses harbored gram-negative bacilli such as *E. cloacae*, Klebsiella, and

Acinetobacter on skin under rings and that some nurses carried the same organism under their rings for months. In a more recent study involving more than 60 ICU nurses, multivariable analysis revealed that rings were the only significant risk factor for carriage of gram-negative bacilli and *S. aureus* and that the concentration of organisms recovered correlated with the number of rings worn (RA Weinstein, personal communication) Whether the wearing of rings results in greater transmission of pathogens is not known. Two studies found that mean bacterial colony counts on hands after handwashing were similar among individuals wearing rings and those not wearing rings.[330,331] Further studies are needed to establish if wearing rings poses an increased risk of transmission of pathogens in healthcare settings.

19. Hand hygiene research agenda

Although the number of published studies dealing with hand hygiene has increased considerably in recent years, many questions regarding hand hygiene products and strategies for improving adherence of personnel to recommended policies remain unanswered. Table 11 lists a number of issues that should be addressed by researchers in industry and by clinical investigators.

Table 1. Studies comparing the relative efficacy (based on log_{10} reductions achieved) of plain soap or antimicrobial soaps versus alcohol-based antiseptics in reducing counts of viable bacteria on hands.

REF #	YEAR	SKIN CONTAMINATION	ASSAY METHOD	TIME (min)	RELATIVE EFFICACY
133	1965	existing hand flora	finger tip agar culture	60	plain soap < HCP < 50% EA foam
118	1975	existing hand flora	handrub broth culture	--	plain soap < 95% EA
105	1978	artificial contamination	finger tip broth culture	30	plain soap < 4% CHG < P-I < 70% EA = alc. CHG
134	1978	artificial contamination	finger tip broth culture	30	plain soap < 4% CHG < 70% EA
106	1979	existing hand flora	handrub broth culture	120	plain soap < 0.5% aq. CHG < 70% EA < 4% CHG < alc.CHG
135	1980	artificial contamination	finger tip broth culture	60-120	4% CHG < P-I < 60% IPA
53	1980	artificial contamination	finger tip broth culture	15	plain soap < 3% HCP < P-I < 4% CHG < 70% EA
107	1982	artificial contamination	glove juice test	15	P-I < alc. CHG
108	1983	artificial contamination	finger tip broth culture	120	0.3-2% triclosan = 60% IPA = alc. CHG < alc. triclosan
136	1984	artificial contamination	finger tip agar culture	60	phenolic < 4% CHG < P-I < EA < IPA < n-P
137	1985	existing hand flora	finger tip agar culture	60	plain soap < 70% EA < 95% EA
109	1986	artificial contamination	finger tip broth culture	60	phenolic = P-I < alc. CHG < n-P
92	1986	existing hand flora	sterile broth bag technique	15	plain soap < IPA < 4% CHG = IPA-E = alc. CHG
60	1988	artificial contamination	finger tip broth culture	30	plain soap < triclosan < P-I < IPA < alc. CHG < n-P
25	1991	patient contact	glove juice test	15	plain soap < IPA-E
138	1991	existing hand flora	agar plate/image analysis	30	plain soap < 1% triclosan < P-I < 4% CHG < IPA
110	1992	artificial contamination	finger tip agar culture	60	plain soap < IPA < EA < alc. CHG
139	1992	artificial contamination	finger tip broth culture	60	plain soap < 60% n-P
111	1994	existing hand flora	agar plate/image analysis	30	plain soap < alc. CHG
140	1999	existing hand flora	agar plate culture	N.S.	plain soap < commercial alcohol mixture
141	1999	artificial contamination	glove juice test	20	plain soap < 0.6% PCMX < 65% EA
142	1999	artificial contamination	finger tip broth culture	30	4% CHG < plain soap < P-I < 70% EA

Existing hand flora = without artificially contaminating hands with bacteria
alc. CHG = alcoholic chlorhexidine gluconate
aq. CHG = aqueous chlorhexidine gluconate
4% CHG = chlorhexidine gluconate detergent
EA = ethanol
HCP = hexachlorophene soap/detergent
IPA = isopropanol
IPA-E = isopropanol + emollients
n-P = n-propanol
PCMX = para-chloro-meta-xylenol detergent
P-I = povidone-iodine detergent
N.S. = not stated

Table 2. Studies comparing the relative efficacy of plain soap or antimicrobial soap versus alcohol-containing products in reducing counts of bacteria recovered from hands immediately after use of products for pre-operative cleansing of hands.

REF#	YEAR	ASSAY METHOD	RELATIVE EFFICACY
133	1965	Finger tip agar culture	HCP < 50% EA foam
147	1969	Finger tip agar culture	HCP < P-I < 50% EA foam
100	1973	Finger tip agar culture	HCP soap < EA foam + 0.23% HCP
131	1974	broth culture	plain soap < 0.5% CHG < 4% CHG < alc. CHG
118	1975	hand broth test	plain soap < 0.5% CHG < 4% CHG < alc. CHG
117	1976	glove juice test	0.5% CHG < 4% CHG < alc. CHG
113	1977	glove juice test	P-I < CHG < alc. CHG
116	1978	finger tip agar culture	P-I = 46% EA + 0.23% HCP
112	1979	broth culture of hands	plain soap < P-I < alc. CHG < alc. P-I
115	1979	glove juice test	70% IPA = alc. CHG
137	1985	finger tip agar culture	plain soap < 70% - 90% EA
114	1990	glove juice test, modified	plain soap < triclosan < CHG < P-I < alc. CHG
103	1991	glove juice test	plain soap < 2% triclosan < P-I < 70% IPA
148	1998	finger tip broth culture	70% IPA < 90% IPA = 60% n-P
149	1998	glove juice test	P-I < CHG < 70% EA

alc. CHG = alcoholic chlorhexidine gluconate
CHG = chlorhexidine gluconate detergent
EA = ethanol
HCP = hexachlorophene detergent
IPA = isopropanol
P-I = povidone-iodine detergent

Table 3. Efficacy of surgical handrub solutions in reducing the release of resident skin flora from clean hands (Rotter M[6]) Reprinted with permission.

STUDY	RUB	CONCENTRATION[a] (%)	TIME ( )	MEAN LOG REDUCTION	
				Immediate	Sustained3h ( )
1	n-Propanol	60	5	2.9[b]	1.6[b]
2			5	2.7[b]	NA
3			5	2.5[b]	1.8[b]
4			5	2.3[b]	1.6[b]
5			3	2.9[c]	NA
4			3	2.0[b]	1.0[b]
4			1	1.1[b]	0.5[b]
6	Isopropanol	90	3	2.4[c]	1.4[c]
6		80	3	2.3[c]	1.2[c]
7		70	5	2.4[b]	2.1[b]
4			5	2.1[b]	1.0[b]
6			3	2.0[c]	0.7[c]
5			3	1.7[c]	NA
4			3	1.5[b]	0.8[b]
8			2	1.2	0.8
4			1	0.7[b]	0.2
9			1	0.8	NA
10		60	5	1.7	1.0
7	Isopropanol + chlorhexidine gluc. (w/v)	70+ 0.5	5	2.5[b]	2.7[b]
8			2	1.0	1.5
11	Ethanol	95	2	2.1	NA
5		85	3	2.4[c]	NA
12		80	2	1.5	NA
8		70	2	1.0	0.6
13	Ethanol + chlorhexidine gluc. (w/v)	95+0.5	2	1.7	NA
14		77+0.5	5	2.0	1.5[d]
8		70+0.5	2	0.7	1.4
8	Chlorhexidine gluc. (aq. Sol., w/v)	0.5	2	0.4	1.2
15	Povidone-iodine (aq. Sol., w/v)	1.0	5	1.9[b]	0.8[b]
16	Peracetic acid (w/v)	0.5	5	1.9	NA

NA, not available
[a] volume/volume unless otherwise stated
[b] Tested according to Deutsche Gesellschaft fur Hygiene, and Mikrobiologic (DGHM)-German Society of Hygiene and Microbiology method
[c] Tested according to European Standard prEN
[d] After 4 h

Table 4. Handwashing frequency among healthcare workers.

REF #	YEAR	FREQUENCY OF HANDWASHING EPISODES		
		AVERAGE NO./ TIME PERIOD	RANGE	AVER. NO./HR.
60	1988	5/8 hr	N.S.	
88	1984	5-10/shift	N.S.	
95	2000	10/shift	N.S.	
233	2000	12-18/day	2-60	
97	2000	13-15/8 hr	5-27	1.6-1.8/hr
89	1977	20-42/8 hr	10-100	
332	2000	21/12 hr	N.S.	
232	2000	22/day	0-70	
87	1991			1.7-2.1/hr
17	1998			2.1/hr
239	1978			3/hr
333	1994			3.3/hr

N.S. = Not Stated

Table 5. Average duration of handwashing by healthcare workers.

REF #	YEAR	MEAN / MEDIAN TIME
334	1997	4.7 - 5.3 sec
333	1994	6.6 sec
52	1974	8 - 9.3 sec
84	1984	8.6 sec
85	1994	< 9 sec
86	1994	9.5 sec
87	1991	< 10 sec
253	1990	10 sec
88	1984	11.6 sec
259	1992	12.5 sec
58	1988	15.6 – 24.4 sec
17	1998	20.6 sec
239	1978	21 sec
252	1989	24 sec

Table 6. Handwashing adherence of healthcare workers.

REF #	YEAR	SETTING	BEFORE /AFTER CONTACT	ADHERENCE BASELINE	ADHERENCE AFTER INTERVENTION	INTERVENTION
240	1981	ICU	A	16%	30%	More convenient sink locations
248	1981	ICU	A	41%	--	
		ICU	A	28%	--	
249	1983	All wards	A	45%	--	
241	1986	SICU	A	51%	--	
		MICU	A	76%	--	
236	1986	ICU	A	63%	92%	Performance feedback
250	1987	PICU	A	31%	30%	Wearing overgown
251	1989	MICU	B/A	14%/28% *	73%/81%	Feedback, policy reviews, memo, posters
		MICU	B/A	26%/23%	38%/60%	
252	1989	NICU	A/B	75%/50%	--	
253	1990	ICU	A	32%	45%	Alcohol rub introduced
254	1990	ICU	A	81%	92%	Inservices first, then group feedback
255	1990	ICU		22%	30%	
256	1991	SICU	A	51%	--	
257	1991	Pedi OPDs	B	49%	49%	Signs, feedback, verbal reminders to physicians
258	1991	Nursery & NICU	B/A **	28%	63%	Feedback, dissemination of literature, results of environmental cultures
259	1992	NICU/ others	A	29%	--	
70	1992	ICU	N.S.	40%	--	
260	1993	ICUs	A	40%	--	
86	1994	Emerg Room	A	32%	--	
85	1994	All wards	A	32%	--	
245	1994	SICU	A	22%	38%	Automated HW machines available
261	1994	NICU	A	62%	60%	No gowning required
333	1994	ICUs Wards	A A	30% 29%	--	
263	1995	ICU Oncol Ward	A	56%	--	
335	1995	ICU	N.S.	5%	63%	Lectures, feedback, demonstrations
264	1996	PICU	B/A	12%/11%	68%/65%	Overt observation, followed by feedback
265	1996	MICU	A	41%	58%	Routine wearing of gowns and gloves
266	1996	Emerg Dept	A	54%	64%	Signs/distributed review paper
267	1998	All wards	A	30%	--	
268	1998	Pediatric wards	B/A	52%/49%	74%/69%	Feedback, movies, posters, brochures
336	1999	MICU	B/A	12%/55%	--	
73	2000	All wards	B/A	48%	67%	Posters, feedback, administrative support, alcohol rub
270	2000	MICU	A	42%	61%	Alcohol handrub made available
243	2000	MICU CTICU	B/A B/A	10%/22% 4%/13%	23%/48% 7%14%	Education, feedback, alcohol gel made available
271	2000	Medical wards	A	60%	52%	Education, reminders, alcohol gel made available

ICU = intensive care unit, SICU = surgical ICU, MICU = medical ICU, PICU = pediatric ICU, NICU = neonatal ICU, Emerg = emergency, Oncol = oncology, CTICU = cardiothoracic ICU

* Percent compliance Before/After patient contact

** After contact with inanimate objects

Table 7. Factors influencing adherence to hand hygiene practices. *

A. Observed risk factors for poor adherence to recommended hand hygiene practices

- Physician status (rather than a nurse)
- Nursing assistant status (rather than a nurse)
- Male gender
- Working in an intensive care unit
- Working during the week (vs. week-end)
- Wearing gowns/gloves
- Automated sink
- Activities with high risk of cross-transmission
- High number of opportunities for hand hygiene per hour of patient care

B. Self-reported factors for poor adherence with hand hygiene

- Handwashing agents cause irritations and dryness
- Sinks are inconveniently located/shortage of sinks
- Lack of soap, paper, towel
- Often too busy/insufficient time
- Understaffing/overcrowding
- Patient needs take priority
- Hand hygiene interferes with healthcare worker-patient relation
- Low risk of acquiring infection from patients
- Wearing of gloves/beliefs that glove use obviates the need for hand hygiene
- Lack of knowledge of guidelines/protocols
- Not thinking about it/forgetfulness
- No role model from colleagues or superiors
- Skepticism about the value of hand hygiene
- Disagreement with the recommendations
- Lack of scientific information of definitive impact of improved hand hygiene on healthcare-acquired infection rates

C. Additional perceived barriers to appropriate hand hygiene

- Lack of active participation in hand hygiene promotion at individual or institutional level
- Lack of role model for hand hygiene
- Lack of institutional priority for hand hygiene
- Lack of administrative sanction of non-compliers/rewarding of compliers
- Lack of institutional safety climate

* Adapted from reference [281]

Table 8. Stategies for successful promotion of hand hygiene in hospitals.

Strategy	Tool for change*	Selected references†
1. Education	E (M, S)	73,254,264,284,337
2. Routine observation and feedback	S (E, M)	73,253,264,284,337
3. Engineering control		
Make hand hygiene possible;easy;convenient	S	73,241,284,337
Make alcohol-based handrub available	S	73
(at least in high-demand situations)	S	73,243,270
4. Patient education	S (M)	243,338
5. Reminders in the workplace	S	73,339
6. Administrative sanction/rewarding	S	12,275
7. Change in hand hygiene agent	S (E)	11,66,70,243,270
8. Promote/facilitate skin care for HCW hands	S (E)	66,73,234,235
9 . Obtain active participation at individual and institutional level	E, M, S	73,74,275
10. Improve institutional safety climate	S (M)	73,74,275
11. Enhance individual and institutitional self-efficacy	S (E, M)	73,74,275
12. Avoid overcrowding, understaffing, excessive workload	S	11,73,77,256,340
13. Combine several of above strategies	E, M, S	73,74,254,264,275,284

*The dynamic of behavioral change is complex and involves a combination of education (E), motivation (M), and system change (S).

Only selected references have been listed; readers should refer to more extensive reviews for exhaustive reference lists.[1,8,275,281,341]

Table 9. Elements of healthcare worker educational and motivational programs.

Rationale for hand hygiene, including:

a. potential risks of transmission of microorganisms to patients
b. potential risks of healthcare worker colonization or infection caused by organisms acquired from the patient
c. morbidity, mortality, and costs associated with healthcare-acquired infections

Indications for hand hygiene, including those patient contacts for which potential contamination is not readily apparent to the healthcare worker, such as:

a. contact with a patient's intact skin (e.g., taking a pulse or blood pressure, performing physical examinations, lifting the patient in bed)[25,26,45,48,51,53]
b. contact with environmental surfaces in the immediate vicinity of patients[46,51,53,54]
c. following glove removal[50,57,70]

Techniques for hand hygiene, including:

a. amount of hand hygiene solution
b. duration of hand hygiene procedure
c. selection of hand hygiene agents
    1. Alcohol-based handrubs are the most efficacious agents for reducing the number of bacteria on the hands of personnel. Antiseptic soaps and detergents are the next most effective, and non-antimicrobial soaps are the least effective.[1,158]
    2. soap and water are recommended for visibly soil hands.
    3. waterless antiseptic agents are recommended for routine decontamination of hands for all clinical indications (except when hands are visibly soiled) and as one of the options for surgical hand hygiene.

Methods to maintain hand skin health:

a. lotions and creams can prevent or minimize skin dryness and irritation due to irritant contact dermatitis
b. acceptable lotions or creams to use
c. recommended schedule for applying lotions or creams

Expectations of patient care managers/administrators as evidenced by:

a. written statements regarding the value of, and support for, adherence to recommended hand hygiene practices
b. role models demonstrating adherence to recommended hand hygiene practices[342]

Indications for, and **limitations** of, glove use:

a. hand contamination may occur as a result of small, undetected holes in examination gloves[279,317]
b. contamination may occur during glove removal[50]
c. wearing gloves does not replace the need for hand hygiene[57]
d. failure to remove gloves after caring for a patient may lead to
e. transmission of microorganisms from one patient to another[328]

Table 10. Association between improved adherence with hand hygiene practice and healthcare-acquired infection rates.

Year	Authors	Hospital setting	Significant results	Duration of follow-up
1977	Casewell and Philips	Adult ICU	Reduction in healthcare-acquired infections due to endemic *Klebsiella* spp.	2 years
1982	Maki and Hecht	Adult ICU	Reduction in healthcare-acquired infection rates	N.S.
1984	Massanari and Heirholzer	Adult ICU	Reduction in healthcare-acquired infection rates	N.S.
1990	Simmons et al.	Adult ICU	No effect (Average hand hygiene adherence improvement did not reach statistical significance)	11 months
1992	Doebbeling et al.	Adult ICU	Significant difference between rates of healthcare-acquired infection between two different hand hygiene agents	8 months
1994	Webster et al.	NICU	Elimination of MRSA Reduction of vancomycin use	9 months
1995	Zafar et al.	Newborn nursery	Elimination of MRSA	3.5 years
2000	Larson et al.	MICU/NICU	Significant reduction of VRE rates in the intervention hospital	8 months
2000	Pittet et al.	Hospital-wide	Significant reduction in the annual overall prevalence of healthcare-acquired infections and MRSA cross-transmission rates	5 years

ICU = intensive care unit
NICU = neonatal ICU
MRSA = methicillin-resistant *S. aureus*
MICU = medical ICU
N.S. = not stated

Table 11. Hand hygiene research agenda

Education and promotion

- Provide healthcare workers with better education regarding the types of patient care activities that can result in hand contamination and cross-transmission.
- Develop and implement promotion programs in pre-graduate courses.
- Study the impact of population-based education on hand hygiene behavior.
- Design and conduct studies to determine if frequent glove use should be encouraged or discouraged.
- Determine evidence-based indications for hand cleansing (considering that it might be unrealistic to expect healthcare workers to clean their hands after every patient contact with the patient).
- Assess the key determinants of hand hygiene behavior and promotion among the different populations of healthcare workers.
- Develop methods to obtain top management support.
- Implement and evaluate the impact of the different components of multimodal programs to promote hand hygiene.

Hand hygiene agents and hand care

- Determine the most suitable hand hygiene agents.
- Determine if preparations with persistent antimicrobial activity reduce infection rates more effectively than do preparations whose activity is limited to an immediate effect.
- Study the systematic replacement of conventional handwashing by the use of hand disinfection.
- Develop devices to facilitate the use and optimal application of agents.
- Develop hand hygiene agents with low irritancy potential.
- Study the possible advantages and eventual interaction of hand care lotions, creams, and other barriers to help minimize the eventual toxic impact of hand hygiene agents.

Laboratory-based and epidemiologic research and development

- Develop experimental models for the study of cross-contamination from patient to patient and from environment to patient.
- Develop new protocols for evaluating the in vivo efficacy of agents, considering in particular short application times and volumes that reflect actual use in healthcare facilities.
- Monitor hand hygiene adherence by using new devices or adequate surrogate markers, allowing frequent individual feedback on performance.
- Determine the percentage increase in hand hygiene adherence required to achieve a predictable risk reduction in infection rates.
- Generate more definitive evidence for the impact on infection rates of improved adherence to recommended hand hygiene practices.
- Provide cost-effectiveness evaluation of successful and unsuccessful promotion campaigns.

PART II. RECOMMENDATIONS

These recommendations are designed to improve hand hygiene practices of healthcare workers and to reduce transmission of pathogenic microorganisms to patients and personnel in healthcare settings.

As in previous CDC/HICPAC guidelines, each recommendation is categorized on the basis of existing scientific data, theoretical rationale, applicability, and economic impact. The CDC/HICPAC system for categorizing recommendations is as follows:

Category IA. Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.

Category IB. Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale.

Category IC. Required for implementation, as mandated by federal and/or state regulation or standard.

Category II. Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

No recommendation; unresolved issue. Practices for which insufficient evidence or no consensus regarding efficacy exist.

I. Indications for handwashing and hand antisepsis

A. Wash hands with a non-antimicrobial soap and water or an antimicrobial soap and water when hands are visibly dirty or contaminated with proteinaceous material. (IA) [65]

B. If hands are not visibly soiled, use an alcohol-based waterless antiseptic agent for routinely decontaminating hands in all other clinical situations described in items I.C. through I.K. listed below. (IA) [73,92,156,158,209,243,253,270]

C. On nursing units where an alcohol-based waterless antiseptic agent is available, provide personnel with a non-antimicrobial soap for use when hands are visibly dirty or contaminated with proteinaceous material. It is not necessary, and may be confusing to personnel, to have both an alcohol-based waterless antiseptic agent and an antimicrobial soap available on the same nursing unit. (II)

D. Although waterless antiseptic agents are highly preferable, hand antisepsis using an antimicrobial soap may be considered in settings where time constraints are not an issue and easy access to hand hygiene facilities can be ensured, or in rare instances when a care giver is intolerant of the waterless antiseptic product used in the institution. (IB)

E. Decontaminate hands after contact with a patient's intact skin (as in taking a pulse or blood pressure, or lifting a patient). (IB) [25,45,48,67]

F. Decontaminate hands after contact with body fluids or excretions, mucous membranes, non-intact skin, or wound dressings, as long as hands are not visibly soiled. (IA) [343]

G. Decontaminate hands if moving from a contaminated body site to a clean body site during patient care. (II) [25,53]

H. Decontaminate hands after contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient. (II) [46,53,54]

I. Decontaminate hands before caring for patients with severe neutropenia or other

forms of severe immune suppression. (II)

J. Decontaminate hands before donning sterile gloves when inserting a central intravascular catheter. (IB)[344-348]
K. Decontaminate hands before inserting indwelling urinary catheters or other invasive devices that do not require a surgical procedure. (IB) [25]
L. Decontaminate hands after removing gloves. (IB)[50,57,70]
M. To improve hand hygiene adherence among personnel in units or instances where high workloads and high intensity of patient care are anticipated, make an alcohol-based waterless antiseptic agent available at the entrance to the patient's room or at the bedside, in other convenient locations, and in individual pocket-sized containers to be carried by healthcare workers. (IA)[11,73,156,243,244,270,276]

II. Hand hygiene technique

A. When decontaminating hands with a waterless antiseptic agent such as an alcohol-based handrub, apply product to palm of one hand and rub hands together, covering all surfaces of hands and fingers, until hands are dry. (IB)[247,349] Follow the manufacturer's recommendations on the volume of product to use. If an adequate volume of an alcohol-based handrub is used, it should take 15 to 25 seconds for hands to dry.
B. When washing hands with a non-antimicrobial or antimicrobial soap, wet hands first with warm water, apply 3 to 5 ml of detergent to hands and rub hands together vigorously for at least 15 seconds, covering all surfaces of the hands and fingers. Rinse hands with warm water and dry thoroughly with a disposable towel. Use towel to turn off the faucet. (IB)[89-91,93,350]

III. Surgical hand antisepsis

A. Surgical hand antisepsis, using either an alcohol-based handrub or an antimicrobial soap, is recommended before donning sterile gloves when performing surgical procedures. (IB)[114,207,210,224]
B. To reduce the number of bacteria that may be released from the hands of surgical personnel, while minimizing skin damage related to surgical hand antisepsis, decontaminate hands without using a brush. (IB) [94,114,116,149,218,222-224]

IV. Selection of hand hygiene agents

A. Provide personnel with efficacious hand hygiene products that have low irritancy potential, particularly when used multiple times per shift. (IB)[89,91,97,156,225]
B. To maximize acceptance of hand hygiene products by health personnel, solicit input from care givers regarding the feel, fragrance, and skin tolerance of any products under consideration. The cost of hand hygiene products should not be the primary factor influencing product selection. (IB)[91,92,156,234,236-238]
C. Prior to making purchasing decisions, evaluate the dispenser systems of various product manufacturers or distributors to ensure that dispensers function adequately and deliver an appropriate volume of product. (II)
D. Do not add soap to a partially empty soap dispenser. This practice of "topping off" dispensers may lead to bacterial contamination of soap. (IA)[192,351]

V. Skin care

A. Provide healthcare workers with hand lotions or creams in order to minimize the occurrence of irritant contact dermatitis associated with hand antisepsis or handwashing. (IA)[232,233]
B. Solicit information from manufacturers regarding any effects that hand lotions, creams, or alcohol-based hand antiseptics may have on the persistent effects of antimicrobial soaps being used in the institution. (IB)[162,269,352]

VI. Other Aspects of Hand Hygiene

A. Do not wear artificial fingernails or extenders when providing patient care. (IA)[307-310]
B. Keep natural nails less than ¼ inch long. (II)
C. Wear gloves when it can be reasonably anticipated that contact with blood or other potentially infectious materials, mucous membranes, and non-intact skin will occur. (IC)[313]
D. Remove gloves after caring for a patient. Do not wear the same pair of gloves for the care of more than one patient, and do not wash gloves between patients. (IB)[50,57,279,328]
E. Change gloves during patient care if moving from a contaminated body site to a clean body site. (II)[50,51,57]
F. No recommendation on wearing rings in healthcare settings. Unresolved issue.

VII. Healthcare worker educational and motivational programs

A. As part of an overall program to improve hand hygiene practices of healthcare workers, educate personnel regarding the types of patient care activities that can result in hand contamination and the advantages and disadvantages of various methods used to clean their hands. (II)[73,251,254,258] Include elements listed in Table 11.
B. Monitor healthcare workers' adherence with recommended hand hygiene practices and provide personnel with information regarding their performance. (IA)[73,236,251,254,258,264,268]
C. Encourage patients and their families to remind healthcare workers to decontaminate their hands. (II)[338,353]

VIII. Administrative measures

A. Make improved hand hygiene adherence an institutional priority and provide appropriate administrative support and financial resources. (IB) [73,74]
B. Implement a multidisciplinary program designed to improve adherence of health personnel to recommended hand hygiene practices. (IB)[73,74]
C. As part of a multidisciplinary program to improve hand hygiene adherence, provide healthcare workers with a readily accessible waterless antiseptic agent such as an alcohol-based handrub product. (IA)[73,156,243,253,270,354]

IX. Outcome or process measurements

A. Develop and implement a system for measuring improvements in adherence of healthcare workers to recommended hand hygiene practices. Examples are listed below.
   1. Monitor and record adherence as the number of hand hygiene episodes performed by personnel/number of hand hygiene opportunities, by ward or by service. Provide feedback to personnel regarding their performance.
   2. Monitor the volume of alcohol-based handrub (or detergent used for handwashing or hand antisepsis) used/1000 patient-days.
   3. Monitor adherence to policies dealing with wearing of artificial nails.
   4. When outbreaks of infection occur, assess the adequacy of healthcare worker hand hygiene.

APPENDIX

Anti-microbial spectrum and characteristics of hand hygiene antiseptic agents

Group	Gram-positive bacteria	Gram-negative bacteria	Mycobacteria	Fungi	Viruses	Speed of action	Comments
Alcohols	+++	+++	+++	+++	+++	fast	optimum concentration 60-90%; no persistent activity
Chlorhexidine (2% and 4% aqueous)	+++	+++	+	+	+++	intermediate	persistent activity; rare allergic reactions
Iodine compounds	+++	+++	+++	++	+++	intermediate	causes skin burns: usually too irritating for hand hygiene
Iodophors	+++	+++	+	++	++	intermediate	less irritating than iodine; acceptance varies
Phenol derivatives	+++	+	+	+	+	intermediate	activity neutralized by non-ionic surfactants
Triclosan	+++	++	+	-	+++	intermediate	acceptability on hands varies
Quaternary ammonium compounds	+	++	-	-	+	slow	used only in combination with alcohols; ecologic concerns

Activity: +++ (excellent);
++ (good, but does not include the entire bacterial spectrum);
+ (fair); - (no activity or not sufficient).
Note: Hexachlorophene is not included because it is no longer an accepted ingredient of hand disinfection.

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December 21, 2001

Resource Center
Attention: HHGuide
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Re: Draft Guideline for Hand Hygiene in Healthcare Settings

A coalition of member companies of The Soap and Detergent Association and The Cosmetic, Toiletry, and Fragrance Association submits these comments on the Draft Guideline for Hand Hygiene in Healthcare Settings published by the Centers for Disease Control and Prevention (CDC) and the Department of Health and Human Services (HHS) in the *Federal Register* on November 9, 2001.

While we agree with many of the points made in the guidelines about the benefits of topical antimicrobial products to prevent the transmission of bacteria and viruses, we have identified issues and suggested changes to the draft which we believe more accurately reflect issues associated with topical antimicrobial products and their use.

For your convenience, we have provided references to documents available on the Internet, however we would be pleased to provide paper copies as well. Thank you for consideration of our comments.

Very truly yours,

Francis H. Kruszewski, Ph.D.
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The Soap and Detergent Association

Thomas J. Donegan, Jr.
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The Cosmetic, Toiletry, and Fragrance Association

CTFA is the national trade association representing the cosmetic, toiletry and fragrance industry. Founded in 1894, CTFA has an active membership of approximately 300 companies that manufacture or distribute the vast majority of finished personal care products marketed in the United States. CTFA also includes approximately 300 associate member companies, including manufacturers of raw materials, trade and consumer magazines, and other related industries.

The Soap and Detergent Association is the non-profit trade association representing some 120 North American manufacturers of household, industrial and institutional cleaning products; their ingredients; and finished packaging. SDA members produce more than 90% of the cleaning products marketed in the U.S.

Comments of SDA/CTFA Coalition on
Draft Guideline for Hand Hygiene in Healthcare Settings

For the last seven years, a coalition of the Soap and Detergent Association and The Cosmetic, Toiletry, and Fragrance Association ("Coalition") has been collaborating on scientific and regulatory issues related to topical antimicrobial products including those for hand hygiene in healthcare settings. The Coalition is providing the following comments based on its review of the "Draft Guideline for Hand Hygiene in Healthcare Settings" developed by the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force and the Healthcare Infection Control Practices Advisory Committee.

- **We agree that the prevention of transmission of bacteria and viruses is an important benefit derived from the use of topical antimicrobial products.**

The primary means of defense against the spread of bacterial and viral contaminants from one person to another, or indirectly spread via inanimate objects, is the application of sound principles of personal hygiene, disinfection of contaminated materials, and skin antisepsis. The risk of infection or acquisition of disease from the transmission of microorganisms can be correlated to specific tasks. The exposure, and consequently the risk, to various populations determine the hygiene product performance desired and the attributes necessary to mitigate the risk (e.g. fast acting or persistent).

The importance of the interruption of the spread of bacterial disease in clinical settings has long been recognized. However, in recent years the prevention of the transmission of viral diseases has received increased attention. Many of the active ingredients in use today for topical antibacterial products also have an appropriate antiviral spectrum for use in mitigating the risk of viral disease transmission.

- **The term "healthcare setting" should be defined in Part 1 Section 4.**

Historically, healthcare professional products were considered to be restricted to use in surgery, or by nursing and other hospital personnel. Since the 1970's there have been significant changes in the US healthcare system, including increased interest in infection prevention and self-treatment. Greater reliance is placed on at-home and outpatient care. Thus healthcare is not limited to the traditional clinical setting; it extends from the home through the surgical suite. Healthcare products are used in all of these settings and not just by individuals trained in healthcare professions.

The draft guidelines appear to be written specifically to address the needs of nurses, physicians and other technical staff in clinical settings, i.e. professionally trained individuals in hospitals and clinics. However, we recommend that a

definition of "healthcare setting" be included that explicitly defines the range of settings where use of these practices is recommended. We feel this is important, since in the broader context of healthcare, different practices and active ingredients may be appropriate. For instance, use of triclocarban-containing topical antimicrobial products is appropriate for the mitigation of resident staphylococci known to be associated with atopic dermatitis when used in a daily washing regimen (Breneman *et al.* 1998, 2000). Consequently, we suggest that a definition of "healthcare setting" be added detailing the settings where use of the guideline practices is recommended.

- **The method for achieving hand hygiene in clinical settings should be based on the risks (to both the healthcare staff and to their patients) found in the specific use situation.**

  The Industry Coalition has developed the Healthcare Continuum Model (HCCM) a guideline to the selection of appropriate hand hygiene products in various settings. The fundamental concept of the HCCM is one of situational use. That is, product and procedural decisions should be made based upon the needs of a given situation. We believe the guidelines should be less prescriptive overall, and more strongly teach the evaluation of situational factors in the selection of hand hygiene products. We feel the guideline may place too strong an emphasis on one strategy (hand sanitizers) to the exclusion of other important and appropriate hand hygiene practices. While alcohol hand sanitizers are certainly an increasingly important tool, the best infection control practices are likely to involve a mixed regimen of products, best defined by the particulars of a given situation. The prescriptive approach of the guideline also may preclude the use of future innovative products.

  There are three elements that must be considered in making any recommendation for a given risk situation: hand hygiene practices, hand hygiene products and compliance.

  1. Hand Hygiene Practices -- Practices must be appropriate for the expected use situation. Consideration must be given to the types and levels of soil encountered in the situation, the availability of products and hand washing facilities, and applicable government regulations and guidelines (e.g. OSHA Bloodborne Pathogen Standard 29CFR1910.1030), in determining the most appropriate means of achieving hand hygiene. Practices need thorough review to ensure products are used appropriately.

  2. Hand Hygiene Products – Topical antimicrobial products are regulated as drugs by the US Food and Drug Administration (FDA). Currently, FDA is drafting the OTC monograph regulation for products used specifically in clinical settings. The 1994 Tentative Final Monograph for Healthcare Antiseptic Drug Products ("TFM") 59 Federal Register 31402, (June 17, 1994) lists the active ingredients FDA is considering for

healthcare professional products. As of 1994, two active ingredients were listed as being both safe and efficacious for use in clinical health care settings: alcohol and iodine. Many other ingredients are under consideration including quaternary ammonium compounds, triclosan, triclocarban, and chloroxylenol (PCMX). Additional data have been filed with FDA to support the safety and efficacy of these active ingredients. FDA Docket 75N-183H. In the intervening time, FDA's 1994 TFM recognizes that products containing those ingredients are acceptable for use in clinical settings.

While there are no "ideal" cause and effect studies using topical antimicrobial products, there is an overwhelming body of evidence that supports the benefit of their use especially in clinical situations. In the proposed OTC Monograph, the FDA associates the efficacy of a topical antimicrobial product with its benefit(s) in use via *in vivo* test methods. This establishes a surrogate endpoint in the *in vivo* evaluation that FDA believes reflects the level of reduction needed to achieve a benefit, e.g. the OTC Monograph specifies a 1 $\log_{10}$ reduction in normal skin flora for surgical hand scrubs. A specific product must achieve the FDA-determined level of reduction in surrogate endpoint testing in order to have the indications and label claims for a specific product type.

A surrogate endpoint "threshold" level of efficacy assures the user that appropriate use of the product should provide a benefit. While the statement "[t]he greater the $\log_{10}$ reduction seen following product use, the greater the benefit" may be logical, in practice it may be an oversimplification. Formulations that are highly efficacious yet esthetically unpleasant may lead to poor user compliance. An esthetically pleasant formulation that meets threshold testing requirements, but appears "less efficacious" in the testing than another product with poor esthetics, may provide a greater overall benefit in a given situation because of a better compliance record.

3. Hand Hygiene Compliance -- The most efficacious product in the world is worthless if consumers will not use it or use it improperly. Consumers (including health care personnel) are quick to reject products that are unpleasant esthetically, irritating or difficult to use. Also, compliance with recommended practices increases when the practices are simple and easy to incorporate into a routine.

Based on these considerations, we believe the emphasis in the guidelines should be placed on the adoption of any hand hygiene strategy that is proven to be efficacious in a specific use situation. Specifically:

- Hand sanitizers are effective if used as directed:
  - Where the biological soil load on the hands is low.
  - Where time between patients is limited.
  - When the personnel experience hand dermatitis.

- Traditional washing products are also effective if used as directed:
  - Where handwashing facilities are available.
  - At all levels of soil load including blood and blood products.
  - Where the patient load is such that there is time to wash between patients.

Therefore, we would recommend review of the guideline to reflect that both strategies are valid and appropriate in specified situations.

- **The focus of the "Review of Preparations Used for Hand Hygiene" (Section 9) should be mechanism and spectrum of action, efficacy and compliance within a given situation.**

Part I Section 9 reviews the published literature on the active ingredients. As written, the summary discusses the chemistry of the ingredient, the mechanism and spectrum of action, efficacy, compliance, product contamination and, in one instance, resistance. We believe that discussion of product failures and resistance should not be addressed under each ingredient heading but rather by summary statements.

- Product contamination, i.e. product preservation failure, is the result of poor manufacturing practices or poor user practices and is not due to an inherent flaw of a particular active ingredient. Consequently, it is inappropriate to discuss product contamination in the context of specific active ingredients.

  1. Antimicrobial active ingredients recognized by the FDA for use in topical antimicrobial products have antimicrobial spectra appropriate for the mitigation of bacteria commonly found as resident or transient flora on the skin, e.g. staphylococci, coliforms. However, the spectra of some active ingredients is not so broad as to be effective against many of the bacteria found primarily as environmental contaminants, e.g. pseudomonads, *Serratia*, spore-formers. Consequently, if the base formulation of a topical antimicrobial product is not inherently hostile to bacterial

growth, a chemical preservative is required to assure product quality.

2. Many products are emulsions, i.e. they have a water phase and an oil phase. Bacterial contaminants usually grow in the water phase. Consequently, it is important that the antimicrobial used in preservation is present in the water phase. Many of the antimicrobial active ingredients used in topical antiseptics are oil soluble molecules. Consequently, they are not used in these formulations as preservatives. Their activity is dependent on their release from the oil phase during use.

Manufacturers usually choose a level of preservative that anticipates the level of microbial insult expected during manufacturing and normal consumer use. However, on rare occasions, lapses in good manufacturing practices or conditions do occur. More frequently, users have been known to dilute product, mix incompatible formulations, or add product to contaminated containers. These practices may overwhelm the preservative system. Since all of these instances of contaminated product are due to lapses in good manufacturing or consumer use practices, and are not due to an inherent flaw of a particular active ingredient, we suggest that these references be removed from Sections 9.1, 9.2, 9.5, 9.6, 9.7, and 9.8 and a general statement be included under the heading for Section 9 (before section 9.1) such as: "All products can be adulterated with bacteria either during manufacture or during use leading to product contamination [98,159,174,192,202]. These failures are not limited to any specific ingredient but are due to the overwhelming of the product preservative system by inappropriate practices during manufacture or use. When contaminated, these products can then be vectors in the spread of disease. Thus, careful attention must be paid to follow the label directions for use and storage. Products should not be diluted or other ingredients added to the product unless directed to do so on the label."

- An FDA panel of experts (Joint Meeting of the Nonprescription Drugs and Anti-Infective Drugs Advisory Committees, January 22, 1997) found that resistance to topical antimicrobial active ingredients is not an important public health issue at this time; therefore, discussion of resistance is not recommended beyond a brief review of the issues consistent with current findings and the position of the FDA.

  It has been shown in laboratory tests that increased resistance (measured as an increase in the minimum inhibitory concentration of an active ingredient for a specific bacterium) to antimicrobial ingredients can occur. However, the real world clinical relevance of these results is unclear. There have been few reports of the isolation

of bacteria "resistant" to topical antimicrobial ingredients from environmental samples or even in clinical settings that could be viewed as a "worst-case" scenario. In clinical settings there is a significant pressure on bacteria due to the use of antibiotics as well as a higher frequency of use of disinfectants and antiseptics than would be seen in most other settings.

At use levels, the concentration of active ingredient in topical antimicrobial products usually greatly exceeds (10-100 times) the Minimum Inhibitory Concentration (MIC), even that of the "more resistant" bacterial strains. In contrast, the concentration of antibiotics prescribed are usually at levels one to four times that of the MIC.

Many of the laboratory reports of "resistance" are noted in strains known to be inherently tolerant of antimicrobial ingredients, i.e. they are strains that are known to be outside the antimicrobial spectrum of the active ingredient.

We note that resistance is discussed only for triclosan (Section 9.6); meanwhile there are other references in the literature discussing examples of laboratory resistance to chlorhexidine and quaternary compounds. Consequently we recommend deleting the reference to the resistance issue in section 9.6. As an alternative, a paragraph could be inserted, following the Section 9.0 heading and before 9.1, describing the current status of the science on resistance to topical antimicrobial ingredients, such as: "There are reports in the literature of the potential decrease in susceptibility to topical antimicrobial ingredients following repeated exposure to low levels of the ingredient. Most of these reports are based on laboratory studies. Reports of isolation of such resistant bacteria from the clinical environment are very few. Government advisory committees in both the US and the UK have reviewed the entire resistance issue (FDA Joint Meeting transcript, January 22, 1997; House of Lords document). In both instances it was found that resistance of bacteria to topical antimicrobial ingredients is not a significant threat to public health at this time. Indeed, the appropriate use of disinfectants and topical antimicrobial ingredients is important in preventing the transmission of bacteria including antibiotic-resistant bacteria in the clinical setting.

- **While we are in agreement with most of the guideline recommendations, we suggest consideration of the following:**

    - Organization
        1) We suggest reordering the paragraphs under each bold heading such that the IA recommendations are together, followed by the IB, IC, II, and NR recommendations. This will help the reader.

2) Section IV, Selection of hand hygiene agents should have two major subsections: one for selection of the appropriate agent by healthcare personnel; another for the selection of the appropriate agents by purchasing.
3) The following recommendations are misplaced:
    - Section I, recommendations C and D are not indications for handwashing. These are recommendations for selection of hand hygiene agents and should be in Section IV personnel.
    - Section I, recommendation M would be better placed in Section IV purchasing or VI.
    - Section IV, recommendation D would be better placed in Section VI.
    - Section V, recommendation B would be better placed in Section IV purchasing.

- Section I. We recommend the addition of the following indication: Wash hands with soap (plain or antibacterial) and water or use hand sanitizer at the start of a shift and after using the restroom. Wash hands or use hand sanitizer following any breaks in the workday.

- In Section II Hand hygiene technique and Section III Surgical hand antisepsis, we recommend suggesting that the user follow label directions rather than giving specific directions that may be inappropriate for all product types. As written, the recommendations address specific products and are not product form independent.

- **Specific recommendations regarding the text follow.**

    - Waterless handrubs: Throughout the text, handrubs are variously described as waterless, alcohol-based, alcohol, etc. We would recommend the harmonization of these references by using the term "hand sanitizer". Recent market research indicates health care professionals have the highest awareness of the term "hand sanitizer". "Waterless" can be confusing implying that the product does not contain water or should not be used near water. Since there are currently in the market hand sanitizers containing benzethonium chloride as the active ingredient as well as other product types containing alcohols, we recommend modifying the term with the active ingredient where that is appropriate (e.g. alcohol hand sanitizer when specifically referring to products containing an alcohol active ingredient).

    - p.8 Persistent activity. The term persistence has been used to describe a number of phenomena over the years, including substantivity, activity over time, and activity after a number of applications. This has led to a certain degree of confusion. The

Industry Coalition has been working with FDA to clarify these terms, and we recommend that consideration be given to using the following definitions in the guideline. These definitions have been presented to FDA by the Industry Coalition:

Persistence is defined as the prolonged or extended antimicrobial activity that prevents or inhibits the proliferation or survival of microorganisms after application of a product. This may be demonstrated by sampling a site several minutes or hours after application and demonstrating bacterial antimicrobial effectiveness when compared to a baseline level. Both substantive and non-substantive active ingredients can show a persistent effect if they lower the number of bacteria significantly during the wash period.

Cumulative effect is defined as a progressive decrease in the numbers of microorganisms recovered following repeated applications of a test material. Cumulative effect should not be confused with persistence that is time, rather than application dependent.

Substantivity is an attribute of some active ingredients that adhere to the stratum corneum, remaining on the skin after rinsing or drying to provide an inhibitory effect on the growth of bacteria remaining on the skin.

- p.8 *Plain soap*. We recommend striking the second sentence of the definition as it applies only to certain formulations, primarily bar soaps. Also, there are many formulations that use surfactants other than alkyl carboxylate salts.

- p.8 *Food and Drug Administration (FDA) product categories*. To provide consistency, we recommend that the language used by the FDA for definition of these products be used, 59 Federal Register 31402, at 31442 (June 17, 1994).

- p.11 line 9. The word "lower" is omitted. It should read ...acquired infection rates were lower when...

- p. 11 line 30 and p. 29 line 11. We recommend striking the word "quasi-experimental".

- p.12 paragraph 2. This paragraph does not accurately reflect either the recommendations in the 1994 TFM or the most recent ASTM versions of these methods. The 1994 TFM modifies some of the then established ASTM methods in ways that the Industry Coalition feels compromises their validity. The Industry Coalition has met with FDA to discuss the specifics of the methods presented in the 1994 TFM and

has recommended that the Agency reference the most current ASTM method. ASTM is a third party consensus building organization that publishes and continually updates methods including those appropriate for topical antimicrobial products. These methods represent the current best practice in the industry. As the recommendations in the 1994 TFM make modifications of the ASTM methods that are not endorsed by the ASTM, or by the coalition, we recommend you cite the most recent version of the methods. These are: ASTM E1115-91 for surgical hand scrub products, and ASTM E1174-00 for healthcare personnel handwash products.

- p.16 Section 9.5. paragraph 1 sentence 2. We suggest rephrasing this sentence: However, because iodine often causes irritation and discoloring of skin, iodophors are more frequently used as a source of iodine in hygienic handwashes and surgical scrubs.

- p.16 Section 9.6 The correct FDA drug nomenclature for PCMX is chloroxylenol. We recommend replacement of all PCMX references to reflect this. A notation that chloroxylenol is also known as PCMX and para-chloro-meta-xylenol should also be added. The concentration of chloroxylenol antimicrobial products on the market today ranges from 0.3 – 3.75%.

- p.18 Section 9.7. Benzethonium chloride is misspelled throughout the section.
- p.18 Section 9.8. In these various products, concentrations ranging from 0.1% to 2% have demonstrated antimicrobial activity.
- p.19 Section 9.9. In your discussion of other agents, no mention is made of triclocarban, an active ingredient listed by FDA for topical antimicrobial ingredients. While triclocarban has rarely been used in hospital products, future innovation may permit its use in clinical settings.

- p. 22 paragraph 1; p.23 paragraph 1. OSHA's 1994 Bloodborne Pathogen Standard differs in its treatment of waterless antiseptics from your proposed guideline. OSHA appears to view hand sanitizers as only a stopgap measure following contamination of the hands with blood/blood products, and that hands should be washed with soap and water as soon as possible thereafter. There is potential confusion between the two guidelines. We recommend that you engage OSHA to harmonize recommendations regarding use of these products.

- p. 24 paragraph 1, last sentence. We recommend giving this sentence greater prominence in the document by incorporating it into the executive summary.

- p.25 paragraph 4, bullet (i) should read alcohol-based formulations containing emollients for hand…

- p.29 paragraph 4, line 6. Strike the word "attack".

- p.41 Table 9 Techniques Subsection c. We recommend reordering the bullets so that the current #2 is 1st, current number 3 is 2nd, and current #1 is 3rd.

- p.43 Table 11 "Hand hygiene agents and hand care."

    1. It is inappropriate that a guidance body should determine a single "most suitable" hand hygiene agent. The choice of a specific hand hygiene agent should be based on the risks in the situation where it is going to be used drawing on a variety of products and ingredients that can be used in a given situation. Your committee should provide guidance on how to make those decisions and the guidance should have flexibility to allow the selection of products that are suitable for a given situation based on practices and compliance, not on characteristics of the product such as the active ingredient or product form.

    2. The last bullet intimates that hand hygiene agents have a "toxic impact". We suggest striking "eventual toxic" and replacing it with "potential irritation".

- p. 45 Section III Bullet B. There are many FDA-approved devices that deliver antimicrobial ingredients via a brush. Additionally, there are many efficacious products that recommend use of a brush in their label directions. Finally, the purpose of a surgical hand scrub is to reduce the number of bacteria that are released from the hands of surgical personnel. Therefore, we suggest rephrasing that bullet: "Use of a brush during surgical hand scrubbing is not recommended UNLESS directed to use a brush by a product label, or where the brush is the primary delivery system of the antimicrobial agent."

- p.46 Section VI Bullet B. We suggest rephrasing this as: Keep natural nail tips less than…

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American Society for Testing and Materials. ASTM E1174-2000 Standard Test Method for Evaluation of the Effectiveness of Health Care Personnel or Consumer Handwash Formulations. *Annual Book of ASTM Standards* 2001, Volume 11.05, West Conshohocken, PA.

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Transcript, Joint Meeting of the Nonprescription Drugs and Anti-Infective Drugs Advisory Committees, January 22, 1997

Designation: E 1115 – 91

Standard Test Method for Evaluation of Surgical Hand Scrub Formulations[1]

This standard is issued under the fixed designation E 1115; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is designed to evaluate antimicrobial agents in formulations for utility and effectiveness as surgical hand scrubs. It is intended for determining both immediate microbial reductions and reductions with regular use (residual effects).

NOTE 1—A knowledge of microbiological techniques is required for these procedures.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standard:*

E 1054 Practices for Evaluating Inactivators of Antimicrobial Agents Used in Disinfectant, Sanitizer, Antiseptic, or Preserved Products[2]

2.2 *Other Documents:*

Standard Method for the Examination of Dairy Products[3]

AATCC Method 90-1965[4]

3. Summary of Test Method

3.1 This test method is conducted on panelists selected from a group of volunteers who have refrained from using any antimicrobials for at least two weeks prior to initiation of the test. At least twelve panelists are selected from this group on the basis of high initial bacteria count, 1×10^5 per hand as determined by baseline measurements of the bacteria on their hands.

3.2 The selected panelists perform a simulated surgical scrub under the supervision of an individual competent in aseptic technique. One-third of the panelists' hands are sampled immediately after the scrub (within 5 min), one-third after 3 h and the remaining hands, 6 h after scrubbing. No more than one hand of a panelist is sampled at a given time interval.

3.3 Ten additional scrubs are performed with the test formulation over a 5-day period following the initial scrub. The hands are sampled two additional times, once after the second scheduled use of the product and again after the last scheduled scrub.

4. Significance and Use

4.1 The procedure in this test method should be used to evaluate the ability of a test formulation to reduce the bacterial population of the hands immediately after a single and multiple use and to determine the trend in growth over a 6-h period after single and multiple usages.

5. Apparatus

5.1 *Colony Counter*—Any of several types may be used, for example, Quebec Colony Counter.

5.2 *Incubator*—Any incubator capable of maintaining a temperature of 30 ± 2°C may be used.

5.3 *Sterilizer*—Any suitable steam sterilizer capable of producing the conditions of sterility is acceptable.

5.4 *Timer (stop-clock)*, that can be read for minutes and seconds.

5.5 *Hand Washing Sink*—A sink of sufficient size to permit panelists to wash without touching hands to sink surface or other panelists.

5.5.1 *Water Faucet(s)*, to be located above the sink at a height that permits the hands to be held higher than the elbows during the washing procedure. (It is desirable for the height of the faucet(s) to be adjustable.)

5.6 *Tap Water Temperature Regulator and Temperature Monitor*, to monitor and regulate water temperature to 40 ± 2°C.

6. Materials and Reagents

6.1 *Petri Dishes*—100 by 15 mm. Required for performing standard plate count.[5]

6.2 *Bacteriological Pipets*, 10.0 and 2.2 or 1.1-mL capacity.[6]

6.3 *Water-Dilution Bottles*—Any sterilizable glass container having a 150 to 200-mL capacity and tight closures may be used.[7]

6.4 *Baseline Control Soap*—A liquid castile soap or other liquid soap containing no antimicrobial.

6.5 *Gloves*—Sterile loose fitting gloves of latex, unlined,

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[1] This test method is under the jurisdiction of ASTM Committee E-35 on Pesticides and is the direct responsibility of Subcommittee E35.15 on Antimicrobial Agents.

Current edition approved July 15, 1991. Published September 1991. Originally published as E 1115 – 86. Last previous edition E 1115 – 86.

[2] *Annual Book of ASTM Standards*, Vol 11.05.

[3] Available from American Public Health Association, Inc., Washington, DC, Chapter: Standard Plate Count Method.

[4] *AATCC Test Methods*, 1968 Technical Manual, Section B-175, available from the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

[5] Presterilized/disposable plastic petri dishes are available from most local laboratory supply houses.

[6] Presterilized/disposable bacteriological pipets are available from most local laboratory supply houses.

[7] Dilution bottles of 160-mL capacity having a screw-cap closure are available from Corning Glass Co., Kimble Glass Co. or most local laboratory supply houses.

possessing no antimicrobial properties.[8]

6.6 *Test Formulation*—Directions for use of test formulation should be included if available. If none are available, use directions provided in this test method (see Section 11).

6.7 *Sampling Solution*[9]—Dissolved 0.4 g KH_2PO_4, 10.1 g Na_2HPO_4 and 1.0 g isooctylphenoxypolyethoxyethanol[10] in 1 L distilled water. Adjust to pH 7.8. Dispense in 75 mL volumes into water dilution bottles, or other suitable containers, and sterilize for 20 min at 121°C. Include an antimicrobial inactivator specific for the test formulation being evaluated in the sampling solution used to collect the bacterial samples from the hand following the final wash with the test formulation.

6.8 *IMPORTANT*—A definitive recommendation regarding the inclusion of an inactivator in sampling solution (6.7) used for bacterial collections prior to the final wash can not be made. The following two points should be considered in making a decision: (*1*) If an inactivator is included in the sampling solution used prior to the final wash, will residual inactivator on the skin reduce the efficacy of the test formulation in subsequent washes and result in higher than expected bacterial counts? (*2*) Can samples collected without an inactivator be processed quickly enough to avoid decreased bacterial count due to continued action of the test formulation? Whatever the decision, to facilitate the comparison of results across studies, the investigator should indicate whether or not an inactivator has been included.

6.9 *Dilution Fluid*—Butterfield's[11] phosphate buffered water adjusted to pH 7.2 and containing an antimicrobial inactivator specific for the test formulation.

6.10 *Soybean-casein Digest Agar*[12], with supplemental polysorbate 80 (0.5 to 10 g/L) to stimulate growth of lipophilic organisms.

6.11 *Fingernail Cleaning Sticks*, such as Pre-Op® Premium Nail Cleaner.[13]

6.12 *Sterile Hand Scrub Brushes*[14] (required only if specified for use with test formulation).

7. Test Panelists

7.1 Panelists shall consist of healthy adult volunteers who have no clinical evidence of dermatosis, have not received antibiotics or taken oral contraceptives two weeks prior to the test, and who agree to abstain from these materials until the conclusion of the test.

8. Preparation of Volunteers

8.1 At least two weeks prior to start of the test, enroll approximately 20 volunteers as potential test subjects.

8.2 Instruct the volunteers to avoid contact with antimicrobials (other than the test formulation) for the duration of the test. This restriction includes antimicrobial-containing antiperspirants, deodorants, shampoos, lotions, soaps, and materials such as acids, bases, and solvents. Bathing in chlorinated pools and hot tubs is to be avoided. Volunteers are to be provided with a kit of nonantimicrobial personal care products for exclusive use during the test and rubber gloves to be worn when contact with antimicrobials can not be avoided.

9. Procedure

9.1 After panelists have refrained from using antimicrobials for at least two weeks, perform wash with baseline control soap (see 5.4, and Section 10). Volunteers are not to have washed their hands on this day 2 h prior to baseline determination. After washing, determine first estimate of baseline bacterial population by sampling hands and enumerating the bacteria in the sampling solution. This is Day 1 of "Baseline Period." Repeat this baseline determination procedure on Days 3 and 7, Days 3 and 5, or Days 5 and 7 of "Baseline Period" to obtain three estimates of baseline population. After obtaining the first and second estimates of the baseline populations, select, as panelists, at least twelve volunteers who exhibited at each sampling intervals, counts 1×10^5. The three estimates of the baseline population, obtained for each of the twelve selected subjects, are averaged to obtain the mean baseline counts.

9.2 A basic random sampling plan should be followed. The number of panelists and sampling times depend on the test formulation but must establish the onset and extent of the bacterial suppression and the duration of suppression below the baseline counts. Equal numbers of panelists should be assigned for sampling time, drug and handedness. A typical balanced randomization plan for testing a block of panelists follows:

Panelists No.	Post Scrub Sampling Time, hour		
	0-h	3-h	6-h
1	left hand	right hand	
2	left hand		right hand
3	right hand	left hand	
4	right hand		left hand
5		left hand	right hand
6		right hand	left hand

9.2.1 The number of panelists per block may vary but must be devisable by two and by the number of sampling times in order to assign equal number of left and right hands to each sampling time.

9.2.2 The minimum number of panelists depend on variability encountered in the study and relative efficacy of drugs. Use of less than twelve panelists each per drug is not advised for final product evaluations. In using larger numbers of panelists, it is only necessary to increase the number of balanced blocks.

9.3 No sooner than 12 h, nor longer than 4 days after completion of their baseline determination, panelists perform initial scrub with the test formulation. Determine, according to the random sampling plan, bacterial populations on the panelists' hands at the assigned sampling interval (0 h, 3 h, 6 h) after scrubbing. Determine bacterial

[8] A suitable glove, Pharmaseal® 8873C, (sterile) Flexam Latex Procedure Glove from American Pharmaseal Laboratories, Glendale, CA 91209. A zone of inhibition test such as AATCC Test Method 90-1965 may be used to evaluate antimicrobial properties of gloves.

[9] Peterson, A. F., "The Microbiology of the Hands: Evaluating the Effects of Surgical Scrubs," *Developments in Industrial Microbiology*, Vol 14, pp. 125–130.

[10] Triton X-100, available from Rohm and Haas Co., Philadelphia, PA.

[11] Butterfield's Phosphate Buffer, *Journal of the Association of Official Agricultural Chemist*, Vol 27, 1939, p. 625.

[12] *United States Pharmacopeia*, XX: United States Pharmacopeial Convention, Inc., Rockville, MD. Chapter: Microbial Limit Test.

[13] Pre-Op® Premium Nail Cleaner (Plastic), Product No. 8014-12, Manufactured by Davis and Geck Laboratory, One Caster St., Danbury, CT 06813.

[14] A suitable brush, Hand Scrub Brush, Wood, No. 3390, is available from Graham Field Surgical Co., Inc., New Hyde Park, NY 11040.

population by sampling hands and enumerating the bacteria in the sampling solution as specified in Sections 13 and 14. Repeat this scrubbing and sampling procedure the next day (Day 2). On Day 5, repeat the sampling procedure after scrubbing with the test material two additional times on Day 2 and three times per day on Day 3 and Day 4 with at least a 1-h interval between scrubs. Perform one scrub on Day 5 prior to sampling. In summary, the panelists scrub a total of eleven times with the test formulation, once on Day 1 and Day 5 and three times per day on Days 2, 3, and 4. Collect bacterial samples following three of the eleven scrubs. Collect the samples following the single scrubs on Days 1 and 5 and following the first scrub on Day 2. This mimics typical usage and permits determination of both immediate and longer-term reductions.

10. Washing Technique for Baseline Determinations

10.1 Volunteers clean under fingernails with nail stick and clip fingernails to ≤2-mm free edge. Remove all jewelry from hands and arms.

10.2 Rinse hands including two thirds of forearm under running tap water 38 to 42°C for 30 s. Maintain hands higher than elbows during this procedure and steps outlined in 10.3, 10.4, and 10.5.

10.3 Wash hands and forearms with baseline control soap for 30 s using water as required to develop lather.

10.4 Rinse hands and forearms, thoroughly removing all lather, for 30 s under tap water.

10.5 Don rubber gloves (6.5) used in sampling hands and secure gloves at wrist.

11. Surgical Scrub Technique to Be Used Prior to Bacterial Sampling

11.1 Repeat 10.1 and 10.2.

11.2 Perform surgical scrub with test formulation in accordance with directions furnished with formulation.

NOTE 2—If no instructions are provided with the test formulation, use the 10-min scrub procedure in 11.3.

11.3 *Ten-Minute Scrub Procedure:*

11.3.1 Dispense formulation into hands.

11.3.2 Set and start timer for 5 min (time required for the steps in 11.3.3 through 11.3.7).

11.3.3 With hands, distribute formulation over hands and lower two thirds of forearms.

11.3.4 If scrub brush is to be used, pick up with finger tips and pass under tap to wet without rinsing formulation from hands.

11.3.5 Alternatively scrub right hand and lower two thirds of forearm and left hand and lower two thirds of forearm.

11.3.6 Rinse both hands, the lower two thirds of forearms, and the brush for 30 s.

11.3.7 Place brush in sterile dish within easy reach.

11.3.8 Repeat 11.3.1 through 11.3.6 so that each hand and forearm is washed twice. The second wash and rinse should be limited to the lower one third of the forearms and the hands.

11.3.9 Perform final rinse. Rinse each hand and forearm separately for 1 min per hand.

11.3.10 Don rubber gloves (6.5) used in sampling hands and secure at wrist.

12. Surgical Scrub Technique When Bacterial Samples Are Not Indicated

12.1 Perform technique as described in Section 11, except omit 11.3.10. Panelists dry hands with clean paper towel after final rinse of hands.

13. Sampling Techniques

13.1 At specified sampling times, aseptically add 75 mL of sampling solution (6.7) to glove and hand to be sampled and occlude glove above wrist.

13.2 After adding sampling solution, uniformly massage all surfaces of hand for 1 min.

13.3 After massaging, aseptically sample the fluid of the glove.

14. Enumeration of Bacteria in Sampling Solution

14.1 Enumerate the bacteria in the sampling solution by a standard plate count procedure such as that described in Standard Methods for the Evaluation of Dairy Products[3] but using soybean-casein digest agar (6.9) and a suitable inactivator[15] for the antimicrobial where necessary. Prepare sample dilutions in dilution fluid (6.8). Plate in duplicate. Incubate plated sample at 30 ± 2°C for 48 h before reading.

15. Determination of Reduction Obtained

15.1 Determine at each sampling interval, changes from baseline counts obtained with test material.

15.2 For a more realistic appraisal of the activity of products, all raw data should be converted to common (base 10) logarithms. Reductions should be calculated from the average of the logarithms. This will also facilitate statistical analysis of data if desired.

16. Comparison of Test Materials With a Control Material

16.1 It may be desirable to compare the test material with a control material. If this is the case, an equivalent number of panelists should be assigned to the control product on a random basis. All test parameters will be equivalent for both products, although the scrub procedure for an established product may be different. Both products should be run concurrently. Identity of products used by panelists should be blinded from those counting plates and analyzing data. A suggested positive control is a surgical scrub formulation approved by the U.S. Food and Drug Administration.

16.2 Compare, at each sampling interval, changes from baseline counts obtained with test material to changes obtained with control material.

17. Precision and Bias

17.1 A precision and bias statement can not be made for this test method at this time.

18. Keywords

18.1 antimicrobial; efficacy; glove juice; surgical scrub

[15] If suitable inactivator for antimicrobial is not known, tests should be performed to determine appropriate neutralizer. A suitable test is described in Practices E 1054.

Designation: E 1174 – 00

Standard Test Method for Evaluation of the Effectiveness of Health Care Personnel or Consumer Handwash Formulations[1]

This standard is issued under the fixed designation E 1174; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is designed to determine the effectiveness of antimicrobial handwashing agents for the reduction of transient microbial flora when used in a handwashing procedure.

1.2 A knowledge of microbiological techniques is required for these procedures.

1.3 In this test method metric units are used for all applications, except for distance in which case inches are used and metric units follow in parentheses.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For more specific precautionary statements see Note 1.

1.5 This method may be used to evaluate topical antimicrobial handwash formulations.

1.6 Performance of this procedure requires the knowledge of regulations pertaining to the protection of human subjects.[2]

2. Referenced Documents

2.1 *ASTM Standards:*

E 1054 Practices for Evaluating Inactivators of Antimicrobial Agents Used in Disinfectant, Sanitizer, Antiseptic, or Preserved Products[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *test organism*—an applied inoculum of an organism that has characteristics which allow it to be readily identified. The test organism is used to simulate a transient topical microbial contaminant. It may also be referred to as a marker organism, bacterial simulant, or bacterial contaminant.

3.1.2 *resident microorganisms*—microorganisms that live and multiply on the skin, forming a permanent population.

3.1.3 *transient microorganisms*—organisms from the environment that contaminate but do not normally colonize the skin.

3.1.4 *active ingredient*—a substance added to a formulation specifically for the inhibition or inactivation of microorganisms.

3.1.5 *test formulation*—a formulation which incorporates antimicrobial ingredient(s).

3.1.6 *neutralization*—a process which results in quenching the antimicrobial activity of a test material. This may be achieved through dilution of the test material(s) to reduce the antimicrobial activity, or through the use of chemical agents, called neutralizers, to eliminate antibacterial activity.

3.1.7 *cleansing wash*—a non-antimicrobial wash intended to remove gross soil or residues from the hands of the panelists prior to the conduct of the study and as noted throughout the study. This may also be referred to as a cosmetic wash.

3.1.8 *healthcare personnel handwash*—a cleanser or waterless agent intended to reduce transient bacteria on the hands.

4. Summary of Test Method

4.1 This test method is conducted on a group of volunteer panelists who have refrained from using topical antimicrobial formulations for at least one week prior to the initiation of the test. Activity of the test material is measured by comparing the number of test organisms recovered from artificially contaminated hands after use of a handwashing formulation to the number recovered from contaminated hands not exposed to the test formulation. The method describes specific procedures to be followed using *Serratia marcescens* as the test organism. The activity of the test material may be measured following a single wash and multiple washes in a single clay using a neutralization recovery method.

4.2 An alternative test organism is *Escherichia coli*. Culture media and incubation conditions appropriate for this organism should be employed. The investigator should also be aware that there may be health risks associated with the use of this organism and precautions similar to those referenced in Note 1 should be undertaken.

5. Significance and Use

5.1 The procedure may be used to test the effectiveness of antimicrobial handwashing agents. The test formulations may be designed for frequent use to reduce the transient bacterial flora on hands.

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[1] This test method is under the jurisdiction of ASTM Committee E35 on Pesticides and is the direct responsibility of Subcommittee E35.15 Antimicrobial Agents.

Current edition approved August 10, 2000. Published November 2000. Originally published as E 1174 – 87. Last previous edition E 1174 – 94.

[2] *Federal Register*, Vol 46, No. 17, Jan. 27, 1991.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

6. Apparatus

6.1 *Colony Counter*—Any of several types may be used, for example, Quebec Colony Counter.

6.2 *Incubator*—Any incubator capable of maintaining the following temperatures: *S. marcescens* (25 ± 2°C) or *E. coli* (35 ± 2°C). This temperature is required to ensure pigment production for *S. marcescens*.

6.3 *Sterilizer*—Any suitable steam sterilizer capable of producing the conditions of sterilization is acceptable.

6.4 *Timer* (Stop-clock)—One that can be read for minutes and seconds.

6.5 *Handwashing Sink*—A sink of sufficient size to permit panelists to wash without touching hands to sink surface or other panelists.

6.5.1 *Water faucet(s)*—To be located above the sink at a height which permits the hands to be held higher than the elbow during the washing procedure.

6.6 *Tap Water Temperature Regulator and Temperature Monitor*—To monitor and regulate water temperature of 40 ± 2°C.

7. Reagents and Materials

7.1 *Bacteriological Pipettes*—10.0 and 2.2-mL or 1.1-mL capacity.[4]

7.2 *Water Dilution Bottles*—Any sterilizable glass container having a 150–200 mL capacity and tight closures may be used.[5]

7.3 *Erlenmeyer Flask*—2-L capacity for culturing test organism.

7.4 *Cleansing Wash*—A mild, non-antimicrobial solid or liquid soap. (The investigator may choose to use the product vehicle.)

7.5 *Test Material*—Directions for use of the test material may be utilized. If directions are not available, use directions provided in this test method.

7.6 *Gloves*—Loose-fitting, unlined, powder-free gloves which possess no antimicrobial properties, or equivalent.[6] (Plastic bags with low bioburden may be used in place of gloves.)

7.7 *Sampling Solution*—Dissolve 0.4 g KH_2PO_4, 10.1 g Na_2HPO_4 and 1.0 g isooctylphenoxypolyethoxyethanol[7] and with appropriately validated neutralizers in 1-L distilled water. Adjust pH to 7.8 with 0.1 *N* HCl or 0.1 *N* NaOH. Dispense so that final volume after sterilization is 75 ml, sterilized at 121°C.[8]

7.8 *Dilution Fluid*—Sterile Butterfield's Buffer[9] or other suitable diluent, adjusted to pH 7.2 with effective neutralizer for the test material. Adjust pH with 0.1 *N* HCl or 0.1 *N* NaOH. See Test Methods E 1054.

7.9 *Agar*—Soybean-casein digest agar, or other solid media appropriately validated to support growth of the test organism with appropriate neutralizers if needed.

7.10 *Broth*—Soybean-casein digest broth or other liquid media appropriate to support growth of the test organism.

8. Test Organism

8.1 *Serratia marcescens* (ATCC 14756) is to be used as the test organism. This is a strain having stable pigmentation at 25°C.

8.2 *Escherichia coli* (ATCC 11229) is an alternative test organism. When *E. coli* is used, the plating agar should include a suitable indicator (e.g. MUG[10]).

NOTE 1—**Warning:** The application of microorganisms to the skin may involve a health risk. Prior to applying the test organism to the skin, the antibiotic sensitivity profile of the strain should be determined. If the strain is not susceptible to gentamicin, do not use it. If an infection occurs, the antibiotic sensitivity profile should be made available to the attending clinician.

Following the subject's last contamination and wash with the formulation, the subject's hands are to be sanitized by scrubbing with 70% isopropanol solution or equivalent. The purpose of this alcohol scrub is to destroy residual test organisms on the skin.

8.3 *Preparation of Test Organism Suspension*

8.3.1 *S. marcescens*—A homogeneous culture is used to inoculate the hands. The stock culture should be at least two 24 hour broth transfers from the original ATCC culture, but there should be no more than 5 transfers removed from the ATCC culture. From the stock culture of *Serratia marcescens* (ATCC 14756) inoculate the appropriate volume of soybean-casein digest broth (7.10) with 0.1 milliliter of stock culture of *S. marcescens*/100mLs of broth to yield the volume necessary to complete the study. Incubate for 24 ± 4 h at 25°C ± 2°C. Broth should develop a red pigment.

8.3.2 *E. coli*—A homogeneous culture is used to inoculate the hands, the stock culture should be at least two 24 hour broth transfers from the original ATCC culture, but no more than 5 transfers removed from the ATCC culture. From the stock culture of *Escherichia coli* (ATCC 11229) inoculate the appropriate volume of soybean-casein digest broth (7.10) with 0.1 milliliter of stock culture/100mLs of broth to yield the volume necessary to complete the study. Incubate for 24 ± 4 hours at 35 ± 2°C.

8.4 Swirl or shake suspension before the withdrawal of each aliquot. Assay the suspension for number of organisms at the beginning and end of the use period. Do not use a suspension for more than 8 hours. The suspension may not vary more than ± 0.5 $\log_{10}$ cfu/mL over an 8 hour period.

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[4] Presterilized/disposable bacteriological pipettes are available from most local laboratory supply houses.

[5] Milk dilution bottles of 160-mL capacity having a screw-cap closure are available from Corning Glass Co., Kimble Glass Co. or most local laboratory supply houses.

[6] A suitable glove would be Pharmaseal 8873C, (sterile) Flexam Latex Procedure Glove from American Pharmaseal Laboratories, Glendale, CA 91209. A zone of inhibition test such as AATCC Test Method 90-1965 may be used to evaluate antimicrobial properties of gloves, *AATCC Test Methods*, American Association of Textile Chemists and Colorist, 1968 Technical Manual, Section B-75.

[7] Triton X-100, Rohm and Haas Co., Philadelphia, PA.

[8] Peterson, A.F., "The Microbiology of the Hands: Evaluating the Effects of the Surgical Scrubs," *Developments in Industrial Microbiology*, Vol 14, pp. 125–130, 1973.

[9] Horowitz, W. (Ed.) 1980. *Official Methods of Analysis of the AOAC*, 13th Ed., Sec. 46.013 (m), p. 825. Assoc. of Off. Anal. Chemists, Washington, D.C. 1018 pp.

[10] *United States Pharmacopeia XXII*: United States Pharmacopeial Convention, Inc., Rockville, MD, Chapter entitled "Microbial Limits Test." The MUG (4-methylumbelliferyl-β-D-gluconride) substrate is hydrolyzed by β-D-gluconridase to yield a fluorescent end product, 4-methylumbelliferone. β-D-gluconridase is possessed by *E. coli* (ATCC 11229). MUG is incorporated into the appropriate growth medium at 0.05 grams/L.

9. Subjects

9.1 Recruit a sufficient number of healthy adult human volunteers who have no clinical evidence of dermatosis, open wounds, hangnails, or other skin disorders.

9.2 Instruct subjects to avoid contact with antimicrobial products (other than the test material as dispensed for each test wash) for the duration of the test and for at least one week prior to the test. This restriction includes antimicrobial-containing antiperspirants, deodorants, shampoos, lotions and soaps, also such materials as acids, bases and solvents. Bathing in biocide treated pools, hot tubs, or spas should be avoided. Subjects are to be provided with a kit of nonantimicrobial personal care products for exclusive use during the test and rubber gloves to be worn when contact with antimicrobial or harsh chemicals cannot be avoided.

10. Procedure

10.1 After subjects have refrained from using antimicrobial formulations for at least 7 days, they perform a 30 second cleansing wash (7.4) in the same manner that is described for the test and control formulations. This procedure removes oil and dirt and familiarizes the panelists with the washing technique.

10.2 *Hand Contamination*—A liquid suspension of the test organism containing a minimum of 1×10^8 cfu/mL is used. See Table 1.

10.2.1 A 1.5mL aliquot of the test organism suspension is dispensed into the subjects' cupped hands. This aliquot is rubbed over the entire surfaces of the hands for 20 ± 5 s (front and back) not reaching above the wrist. The hands are then held motionless away from the body and allowed to air dry for approximately 30 ± 5 s.

TABLE 1 Hand Contamination with Test Organism Suspension

Volume	Spread Time	Dry Time
1.5 mL	20 sec	30 sec
1.5 mL	20 sec	30 sec
1.5 mL	20 sec	90 sec

10.2.2 To continue the contamination of the hands, an additional 1.5mL aliquot of the test organism suspension is dispensed into the hands, distributed over the hands for 20 ± 5 seconds, and air dried for 30 ± 5 seconds.

10.2.3 To complete the contamination, a final 1.5mL aliquot of test organism suspension is dispensed into the hands, distributed over the hands for 20 ± 5 seconds, and air dried for 90 ± 5 seconds (Table 1).

NOTE 2—The hands may still be wet after the 90 seconds.

10.2.4 The total test organism suspension applied to the hands is 4.5 mL. Contamination may take approximately 5 minutes. This method of contamination minimizes the loss of test organism while spreading.

10.3 *Contamination Schedule*—The subjects' hands are contaminated with the test organism prior to the baseline bacterial sample collection and prior to each washing with the test material. Table 2 below illustrates a typical test. The number of repeated test washes may be reduced or eliminated at the discretion of the investigator.

TABLE 2 Hand Contamination and Recovery Schedule

Name	Contamination	Type of Wash	Recovery
Cleansing Wash	no	Cleansing Wash	no
Baseline	yes	no	Plate Recovered Sampling Solution with Neutralizer
Cleansing Wash	no	Cleansing Wash	no
Test Wash 1	yes	Test Formulation	Plate Recovered Sampling Solution with Neutralizer
Cleansing Wash	no	Cleansing Wash	no
Test Wash 2–10	yes	Test Formulation	no
Test Wash 11	yes	Test Formulation	Plate Recovered Sampling Solution with Neutralizer

10.4 *Baseline Recovery*—A baseline sample is taken after contamination to determine the number of marker organisms surviving on the hands. Bacterial sampling will follow the procedures outlined in Section 12.

11. Wash and Rinse Procedure

11.1 Conduct the test in accordance with the use directions for the test material. If test material directions are not available, the wash and rinse procedure described as follows should be used. Table 2 above shows the contamination and recovery schedule for the overall study.

11.2 *Liquid Formulations*

11.2.1 Dispense 5 ml of test material into cupped hands. Spread over hands and lower ⅓of forearms.

NOTE 3—The 5 ml volume has been chosen for test purposes due to the requirement for washing hands and forearms.

11.2.2 Sparingly wet contaminated hands with 40 ± 2°C tap water.

11.2.3 Wash in a vigorous manner for 30 ± 5 seconds all surfaces of the hands and the lower third of the forearm. Caution should be exercised to retain the test material in the hands. If the lather becomes too dry, a small amount of water may be added to maintain lather.

11.2.4 Rinse thoroughly from fingertips to elbows under 40 ± 2°C tap water for 30 ± 5 seconds. Caution should be exercised to avoid contact with the sink and fixtures to eliminate recontamination from the sink surfaces.

11.2.5 Subject's hands and forearms are lightly patted dry with paper toweling.

NOTE 4—After washes requiring sampling, the hands are not to be dried, but held upright until procedures in 12.1 are performed.

11.3 *Waterless Formulations*[11]

11.3.1 Dispense 5 mL of test material into cupped hands.

NOTE 5—The 5 ml volume has been chosen for test purposes due to the requirement for washing hands and forearms.

11.3.2 Distribute test material over all surfaces of the hands and the lower third of the forearms. Continue rubbing in a

[11] An alternative test methodology may be found in European Standard CEN-1500: Chemical Disinfectants and Antiseptics - Hygenic Handrub - Test Method and Requirements (phase2/step2), July, 1997.

vigorous manner for 30 ± 5 seconds or until dry. Caution should be exercised to retain the test material in the hands.

11.3.3 Subject's hands may be held upright and motionless prior to Bacterial Recovery (Section 12).

11.4 *Solid Formulations*

11.4.1 Sparingly wet contaminated hands and forearms with 40 ± 2°C tap water.

11.4.2 Wet the product.

11.4.3 Rub the product between the hands and on the forearms for 15 ± 3 seconds. Place product aside.

11.4.4 Lather lower third of forearms and hands for an additional 30 ± 5 seconds. If the lather becomes too dry, a small amount of water may be added to maintain lather.

11.4.5 Rinse thoroughly from fingertips to elbows under 40 ± 2°C tap water for 30 ± 5 seconds. Caution should be exercised to avoid contact with the sink and fixtures to eliminate contamination from the sink surfaces.

11.4.6 Subject's hands and forearms are lightly patted dry with paper toweling.

11.5 *Other Product Forms*

11.5.1 Use standardized amount (e.g. weight, volume) of test material in accordance with use directions.

11.6 After washes requiring sampling, the hands are not to be dried, but held upright until procedures in 12.1 are performed.

12. Bacterial Recovery

12.1 Within 5 minutes after specified washes (10.3), place gloves (7.6) used for sampling on the hands. Add 75 mL of sampling solution (7.7) with neutralizer to each glove and secure gloves above the wrist.

12.2 Uniformly massage all surfaces of the hand for 1 min ± 5 seconds.

12.3 Aseptically retrieve a 3-5 mL sample of the fluid in the glove by pulling the glove away from the wrist, inserting a pipet into the finger region of the glove, and withdrawing the fluid.

12.4 The dilution and plating of the recovered sampling solution is completed within 30 minutes after sampling.

13. Enumeration of Bacteria in Sampling Solution

13.1 *S. marcescens*

13.1.1 Enumerate the *S. marcescens* in the recovered sampling solution (12.3) using standard microbiological techniques, such as membrane filtration or spread plating. The pour plate technique is not recommended because subsurface *S. marcescens* colony forming units may not exhibit the red pigment.

13.1.2 Prepare dilutions of the recovered sampling solution (12.3) in dilution fluid (7.8). Use soybean-casein digest agar (7.9) with suitable inactivator as recovery medium.

13.1.3 Incubate prepared plates 48 ± 4 h at 25 ± 2°C. Standard plate counting procedures are used to count only the red pigmented *S. marcescens*.

13.2 *E. coli*

13.2.1 Enumerate the *E. coli* in the sampling solution using standard microbiological techniques, such as membrane filtration, pour or spread plating. Prepare dilutions of the recovered sampling solution (12.3) in dilution fluid (7.8). Use soybean-casein digest agar (7.9) with suitable inactivator and indicator (MUG^{10}) as recovery medium.

13.2.2 Incubate prepared plates 48 ± 4 hour at 35 ± 2°C. Standard plate counting procedures are used to count only the fluorescent (MUG^{10}) *E. coli* colonies. Fluorescent colonies are counted using long-wave UV light.

14. Determination of Reduction

14.1 Convert plate counts (cfu/hand) to $\log_{10}$. Average left and right hands.

14.2 Determine Log_{10} Reductions at each recovery interval/wash using the following formula:

$$\text{Log}_{10}\ \textit{Reduction at Sampling Interval} = \text{Log}_{10}\ \textit{Baseline Recovery} - \text{Log}_{10}\ \textit{Sampling Interval} \quad (1)$$

15. Comparison of Test Material

15.1 It may be desirable to compare the test material with other test formulations. If this is the case, an equivalent number of panelists should be assigned to each formulation on a random basis. All test parameters will be equivalent for products, although the wash procedure for an established product may be different. Both products should be run concurrently.

16. Precision and Bias

16.1 A precision and bias statement cannot be made for this test method at this time.

17. Keywords

17.1 antimicrobial; contaminant; efficacy; handwash; healthcare; marker organism; simulant

Effect of An Antibacterial Bar Soap on Atopic Dermatitis

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ABSTRACT

Patients with atopic dermatitis have a high frequency of colonization with *Staphylococcus aureus*, which may affect the manifestation of the disease by either the direct action of bacteria or their metabolic end products or by an immunologic reaction to the bacterial superantigens. Triclocarban (TCC), an active ingredient in antibacterial soap, is highly effective against the *Staphylococcus* species found on the skin. The purpose of this study was to determine if daily bathing with a commercial antibacterial bar soap with 1.5% TCC would reduce the numbers of *S. aureus* on the skin and result in a clinical improvement in atopic disease and a reduction in the amount of topical steroids used.

Fifty patients with moderately severe atopic dermatitis were given either a commercial antibacterial bar soap with 1.5% TCC or a placebo bar soap, a non-medicated moisturizing cream and a topical steroid containing 0.025% triamcinolone acetonide for 6 weeks. During the 3-week regression period, they stopped using the corticosteroid cream but continued to use their assigned bar soap product and the moisturizing cream.

Patients were assessed before enrollment and during the treatment and regression periods. Microbiological specimens, taken from skin sites on the body, were analyzed to determine the numbers of total aerobic organisms and *S. aureus*. Although both treatment groups improved while following the daily bathing regimen required in the protocol, a dermatologist's assessment of global improvement indicated that there was significantly more overall improvement in the antibacterial group than in the placebo group. The antibacterial group showed significantly lower scores for total primary and secondary dermatological effects and a significant decrease in the percent body area affected by atopic disease. Moreover, the antibacterial soap patients reported less itching. Repeated measures analysis indicated that the antibacterial group showed significantly lower numbers of total organisms and directionally lower numbers of *S. aureus* than the placebo group during both the treatment and regression periods. The 50% of the patients who had *S. aureus* at day 0 had significantly fewer of these organisms in the antibacterial group than in the placebo group during the remainder of the study. The results of this study demonstrate that daily bathing with an antimicrobial soap has advantages over bathing with a placebo soap. The clinical improvements in atopic disease and reductions in the levels of microorganisms were consistently better in the antibacterial group.

1998

The Effect of Antibacterial Soap With 1.5% Triclocarban on *Staphylococcus aureus* in Patients With Atopic Dermatitis

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This double-blind study determined whether daily bathing with an antibacterial soap would reduce the number of Staphylococcus aureus *on the skin and result in clinical improvement of atopic dermatitis. For 9 weeks, 50 patients with moderately severe atopic dermatitis bathed daily with either an antimicrobial soap containing 1.5% triclocarban or the placebo soap. They also used a nonmedicated moisturizer and 0.025% triamcinolone acetonide cream as needed, but the availability of the corticosteroid cream was discontinued after 6 weeks. The antimicrobial soap regimen caused significantly greater improvement in the severity and extent of skin lesions than the placebo soap regimen, which correlated with reductions both in* S aureus *in patients with positive cultures at baseline and in total aerobic organisms. Outcome measures included reductions in* S aureus, *total aerobic organisms, and dermatologic assessments. Overall, daily bathing with an antibacterial soap was well tolerated, provided clinical improvement, and reduced levels of skin microorganisms.*

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REPRINT REQUESTS to University Dermatology Consultants, Inc., University of Cincinnati, 234 Goodman Street, Pavilion A-3, Cincinnati, OH 45267 (Dr. Breneman).
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Approximately 10% to 15% of the population is affected with atopic dermatitis,[1] which causes patients to have high frequencies of skin colonization with *S aureus* and increased numbers of skin flora, acute lesions, and chronic plaques. Clinical studies have shown that the affected skin of 80% to 95% of atopic patients (versus about 5% of controls) is colonized with *S aureus*,[2-4] which is especially dense in the lesions and plaques.[2-4] The levels of *S aureus* colonization have been directly related to the extent and severity of atopic dermatitis.[3,4] *S aureus* is of clinical importance in atopic dermatitis because it can cause secondary skin infections and contribute to the dermatitis.[4] Although the exact mechanism is not known, *S aureus* appears to increase inflammation by the direct action of the bacteria, their metabolic end products on the skin, or an immunologic reaction to the bacterial antigens and superantigens.[10,11]

Clinical studies have shown that treatment with topical antibiotics and antiseptics that reduce the levels of *S aureus* results in improvement in the clinical severity of atopic dermatitis.[3,12-17] However, prolonged use of topical antibiotics can be complicated by the development of bacterial resistance.[3,18,19] Recent reports suggest that topical products containing antimicrobial ingredients may provide similar benefits without this complication.[15,16] One such ingredient, triclocarban (the active ingredient in the antibacterial soap used in this study), is effective against the *Staphylococcus* species that colonizes the skin.[12-14] Washing with an antibacterial soap removes bacteria and deposits the antimicrobial ingredient on the skin,

which can control the number of surviving organisms and help prevent the colonization of pathogens such as *S aureus*.

The purpose of this study was to determine if bathing at least once daily with an antibacterial soap with 1.5% triclocarban would reduce the number of microorganisms, particularly *S aureus*, on the skin and result in clinical improvement in atopic dermatitis. We also investigated whether the use of topical corticosteroids in addition to the antibacterial soap was beneficial.

Methods

Summary of study design—This double-blind, randomized clinical study consisted of a 14-day standardization period to ensure that subjects were using the same products, a 42-day treatment period, and a 21-day regression period. Fifty patients with dermatitis of moderate severity, who had Fitzpatrick skin types I to IV,[22] and who met criteria for the diagnosis of atopic dermatitis specified by Hanifin and Rajka[21] were enrolled and gave informed consent. These patients had active dermatitic lesions manifested by combinations of erythema, scales, lichenification, crusting, and excoriation. The study was reviewed and approved by the Institutional Review Board of the University of Cincinnati prior to its conduct.

During the standardization period, patients were given a nonmedicated cleansing bar and a nonmedicated moisturizing cream to use in place of their regular cleansing and moisturizing products, and they were instructed to refrain from using systemic or topical antibiotics and antibacterial/antimicrobial soap, lotion, cream, and shampoo until after the study was completed. In addition, patients were given a topical corticosteroid cream containing 0.025% triamcinolone acetonide to use in place of other topical corticosteroid medications.

During the treatment period, patients were given either a bar soap (Safeguard®) containing 1.5% triclocarban as the active antimicrobial ingredient or a placebo bar soap identical to the antibacterial bar but without triclocarban. To ensure adequate exposure to the test products, patients were required to thoroughly wash their entire bodies with the assigned product at least once daily. All patients continued on the nonmedicated moisturizer and topical corticosteroid treatment regimen established during the standardization period. This allowed for a comparison of the amount of topical corticosteroid used between the 2 groups to determine if patients using the antibacterial soap required less. The extent of the atopic dermatitis on each patient was assessed, and microbial specimens were taken on days 0 (before beginning the treatment period), 14, 28, and 42.

Patients stopped using all topical corticosteroids during the regression period to determine the rate at which clinical symptoms returned. However, they were allowed to use the moisturizing cream and continued to use their assigned test product daily. Dermatologic evaluations were done on a weekly basis to ensure that the patients' conditions did not become extensively worse. Microbial specimens were taken at the end of this period.

Baseline grading for disease severity—The baseline grading system reported by Rajka and Langeland[23] was used to determine the severity of the patients' atopic dermatitis. Only patients who had atopic dermatitis of moderate severity were enrolled.

Rating the extent and severity of dermatitis—A rating scale was also used to determine the amount of itching experienced by the patient.[11,24] On day 0, only patients with a minimum total evaluation score of 4.0 for the 3 primary attributes in at least one area of the body were allowed to continue into the treatment period. The percentage of the body surface area affected was scored on a scale of 0 to 6 (0=0% affected, 6=90% to 100% affected).[25]

Investigator's global evaluation—To provide an additional perspective into the worsening or improvement of a patient's dermatitis, the investigator scored the change in global atopic dermatitis from day 0 (baseline) to days 14, 28, and 42 after product use and at the weekly visits during the regression period. A scale of −5 to 5 (−5=severe worsening, 0=no change, 5=total clearing) was used to evaluate the extent and severity of dermatitis and skin symptomology.

Use of topical corticosteroids—During the standardization and treatment periods, patients who needed a topical corticosteroid cream were provided with a low-potency cream containing 0.025% triamcinolone acetonide. This cream was selected because reports claim that it did not cause significant quantitative or qualitative changes in the microbial flora of the skin.[26] One 60 g tube was provided to patients at the study enrollment and as needed at their visits to the clinical site. They were instructed to sparingly apply the cream to the affected areas of the skin and limit the applications to only when necessary. Their unused, partially used, or empty tubes were weighed to monitor the amounts of applied cream. Patients were not permitted to use any systemic or topical corticosteroids during the regression period.

Microbiologic sampling—Microbiologic specimens were taken from 4 or 5 skin sites using a swab-wash method.[27] An open circular area of 5.0 cm^2, delineated by a Teflon® template, was wiped with a cotton-tipped swab moistened in 2.0 mL of Letheen broth (Difco® 0681-01-5) for 60 seconds. A total of

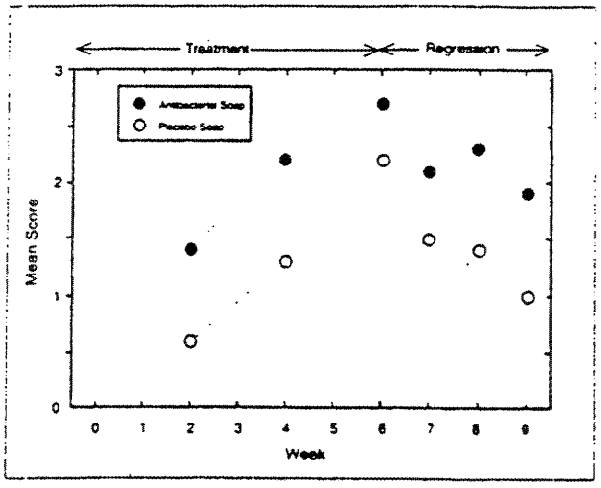

FIGURE 1. Mean global improvement scores throughout the 6-week treatment period and the subsequent regression period when the use of corticosteroid cream was restricted. An assessment of the overall improvement in atopic dermatitis for the antibacterial soap group (•) and the placebo soap group (○) was compared to the baseline assessment on a scale of -5 to 5 (-5=severe worsening, 0=no change, 5=total clearing).

4 specimens were taken from the elbow- and knee-crease areas. If a patient did not have any dermatitic lesions in either of these areas at the visit on day 0, a fifth specimen was taken from a lesional site in another area, not including the back, scalp, or hands. When it was necessary to take a fifth specimen, a sampling of this site was continued throughout the study.

The specimens were plated on trypticase soy agar with 5% sheep blood and on mannitol salt agar for the enumeration of total aerobic organisms and *S aureus*, respectively. Differential counting of the *S aureus* was based on differences in colonial morphology (ie, size, color, general appearance). Identification of *S aureus* was confirmed with a BBL® Staphyloslide® test.

Statistical Analysis

Statistical comparisons were made using repeated measures analysis of variance or covariance over time. For primary and secondary dermatologic attributes, including total aerobic microorganisms, *S aureus*, and itch, changes from baseline were analyzed using baseline response as a covariant and body part as a factor when multiple samples were collected from different areas of the body. Microbiologic data were log transformed prior to analysis. For dermatologist-assessed global change in atopic dermatitis, repeated measures analysis of variance over time was used to make statistical comparisons. Homogeneity at baseline was verified for all endpoints with analysis of variance, and P values $\leq .05$ were considered statistically significant.

Results

This study showed that an antibacterial soap was more beneficial than a placebo soap when used in a daily bathing and treatment regimen for atopic dermatitis. These results were consistent with the dermatologic and microbiologic assessments.

Dermatologic Endpoints—Global improvement in atopic dermatitis was significantly greater in the group that used the antibacterial soap than in the group that used the placebo soap. The scores for both groups tended to improve throughout the entire 6-week treatment period and worsen slightly during the subsequent regression period when use of corticosteroid was restricted; however, the tendency toward worsening was less pronounced in the antibacterial soap group (Figure 1).

In general, the antibacterial soap group showed greater and more rapid improvement with respect to disease extent and severity than did the placebo soap group; they experienced less itching and held this improvement better during the 3-week regression period. Results from analyses of the total of the 3 primary attributes, the total of the 3 secondary attributes, and the total of all 6 dermatologic attributes indicated that the change from baseline scores was significantly greater in the antibacterial regimen compared with the placebo regimen. The results from the analyses of the individual components of the primary and secondary attributes, except for oozing/weeping/crusting, also indicated that the efficacy was significantly higher in the regimen using antibacterial soap than in the one using placebo soap. The prevalence of oozing/weeping/crusting was too low to demonstrate a significant change. The greatest improvement was shown for excoriation. All scores followed the same trends of decreasing during the 6-week treatment period and gradually increasing during the regression period. As with global improvement, the antibacterial group regressed more slowly than the placebo group after discontinuing corticosteroid use. The secondary attributes followed a similar score pattern: there was a significant reduction in the percentage of body surface area affected by atopic dermatitis in the antibacterial group, while the percentage of body surface area affected in the placebo group remained unchanged. No significant differences between the 2 treatment groups were detected at baseline for any of the measured parameters ($P>.05$).

There was no significant difference in the amount of topical corticosteroid used by either treatment group ($P=.86$). During the standardization and treat-

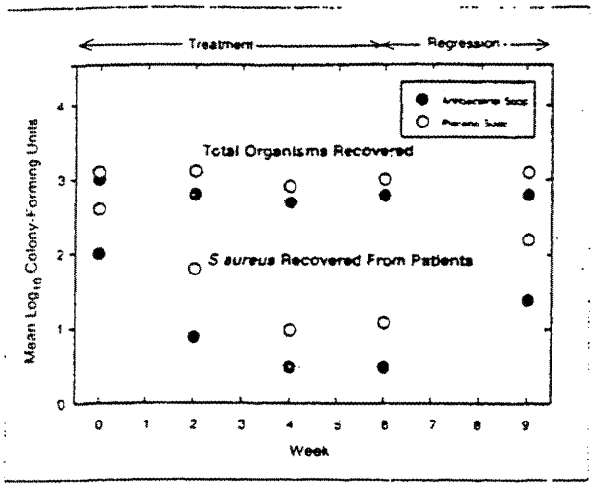

FIGURE 2. Mean $\log_{10}$ colony-forming units (CFUs) recovered from the antibacterial soap group (•) and the placebo soap group (o) during the treatment and regression periods when the use of corticosteroid cream was restricted. (A) Upper graph: CFUs of total organisms recovered from both lesional and nonlesional areas. (B) Lower graph: CFUs of *S aureus* recovered from both lesional and nonlesional areas for the 50% of patients who began the study with a detection of *S aureus*.

ment periods, the average amount of corticosteroid used by the antibacterial and placebo groups was 79.9 and 83.6 mg, respectively. There was only one study-related adverse event: a patient from the antibacterial soap group withdrew at day 28 because of worsening of dermatitis.

Microbiologic endpoints—For the 50% of the patients who began the study with a detection of *S aureus* (22% antibacterial, 28% placebo), the antibacterial soap regimen reduced *S aureus* counts significantly more than the placebo soap regimen. When patients without *S aureus* at the beginning of the study were included in the analysis, there was no significant difference in the reduction of the numbers of *S aureus* between the 2 treatment regimens. The reduction in the total numbers of aerobic organisms was greater in the antibacterial soap group than in the placebo group (Figure 2). The ratio of *S aureus* to total organism counts was significantly lower for patients using the antibacterial soap, and high concentrations of total organisms and *S aureus* tended to be associated with lesional, rather than nonlesional, areas.

Demographics—Thirty-five females and 15 males, aged 12 to 74 years, were included in the study. The mean and median ages were 34.6 and 35 years, respectively. Age distributions ($P=.65$) and gender distributions ($P=.76$) were not significantly different between the 2 treatment groups. Fitzpatrick skin types II, III, and IV were represented by 20, 5, and 25 patients, respectively, and all Fitzpatrick skin types were similarly represented in the 2 treatment groups ($P=.34$).

Discussion

In this study, using an antibacterial soap for daily bathing had advantages over using a nonantibacterial placebo soap in a regimen to treat atopic dermatitis. The clinical improvements, including reductions in the extent and severity of atopic dermatitis, itching, and levels of microorganisms like *S aureus*, were consistently greater in the antibacterial soap regimen than in the placebo soap regimen. In addition, dermatitis in the antibacterial soap group remained less severe than in the placebo soap group during the regression period when corticosteroid use was prohibited. These differences in product efficacy were not impacted by the amount of topical corticosteroids used because the total amounts used by both groups were similar.

The results of this study suggest a correlation between an improvement in atopic dermatitis and a decrease in the number of *S aureus* on the skin. The carriage rate of *S aureus* was lower than the 79% to 95% previously reported for atopic dermatitis (50% at day 0).[2-5] This lower prevalence was likely due to the limited number of skin sites sampled for microorganisms relative to the entire affected body surface area that was assessed during the dermatologic evaluations. However, the results from the dermatologic evaluations strongly suggest that an improvement in atopic dermatitis can occur with even a small decrease in the numbers of *S aureus*.

Patients with atopic dermatitis are frequently instructed to avoid the use of antibacterial soap; however, no significant incident of irritation or irritant contact dermatitis was reported in either group. The results of this study show that regular use of an antibacterial soap containing 1.5% triclocarban may lead to a significant improvement in atopic dermatitis without increasing the incidence of irritation. This type of antibacterial soap may be a useful, well-tolerated, and inexpensive addition to the clinical management of atopic dermatitis.

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6. Rinse test tube and filters with two 1.5 ml aliquots of benzene and filter through the fritted glass funnel.

7. Collect the extract and two rinses in a 10 ml Kontes graduated evaporative concentrator.

8. Evaporate down to 1 ml while rinsing the sides with benzene.

9. Pipet 0.5 ml into the Teflon cup and evaporate to dryness in a vacuum oven at 40 °C for 3 hours.

10. Weigh the Teflon cup and the weight gain is due to the benzene soluble residue in half the Sample.

II. MEDICAL SURVEILLANCE GUIDELINES

A. *General.* The minimum requirements for the medical examination for coke oven workers are given in paragraph (j) of the standard. The initial examination is to be provided to all coke oven workers who work at least 30 days in the regulated area. The examination includes a 14″ × 17″ posterior-anterior chest x-ray reading and a ILO/UC rating to assure some standardization of x-ray reading, pulmonary function tests (FVC and FEV 1.0), weight, urinalysis, skin examination, and a urinary cytologic examination. These tests are needed to serve as the baseline for comparing the employee's future test results. Periodic exams include all the elements of the initial exam, except that the urine cytologic test is to be performed only on those employees who are 45 years or older or who have worked for 5 or more years in the regulated area; periodic exams, with the exception of x-rays, are to be performed semiannually for this group instead of annually; for this group, x-rays will continue to be given at least annually. The examination contents are minimum requirements; additional tests such as lateral and oblique x-rays or additional pulmonary function tests may be performed if deemed necessary.

B. *Pulmonary function tests.*

Pulmonary function tests should be performed in a manner which minimizes subject and operator bias. There has been shown to be learning effects with regard to the results obtained from certain tests, such as FEV 1.0. Best results can be obtained by multiple trials for each subject. The best of three trials or the average of the last three of five trials may be used in obtaining reliable results. The type of equipment used (manufacturer, model, etc.) should be recorded with the results as reliability and accuracy varies and such information may be important in the evaluation of test results. Care should be exercised to obtain the best possible testing equipment.

[41 FR 46784, Oct. 22, 1976, as amended at 42 FR 3304, Jan. 18, 1977; 45 FR 35283, May 23, 1980; 50 FR 37353, 37354, Sept. 13, 1985; 54 FR 24334, June 7, 1989; 61 FR 5508, Feb. 13, 1996; 63 FR 1290, Jan. 8, 1998; 63 FR 33468, June 18, 1998]

§ 1910.1030 Bloodborne pathogens.

(a) *Scope and Application.* This section applies to all occupational exposure to blood or other potentially infectious materials as defined by paragraph (b) of this section.

(b) *Definitions.* For purposes of this section, the following shall apply:

Assistant Secretary means the Assistant Secretary of Labor for Occupational Safety and Health, or designated representative.

Blood means human blood, human blood components, and products made from human blood.

Bloodborne Pathogens means pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus (HBV) and human immunodeficiency virus (HIV).

Clinical Laboratory means a workplace where diagnostic or other screening procedures are performed on blood or other potentially infectious materials.

Contaminated means the presence or the reasonably anticipated presence of blood or other potentially infectious materials on an item or surface.

Contaminated Laundry means laundry which has been soiled with blood or other potentially infectious materials or may contain sharps.

Contaminated Sharps means any contaminated object that can penetrate the skin including, but not limited to, needles, scalpels, broken glass, broken capillary tubes, and exposed ends of dental wires.

Decontamination means the use of physical or chemical means to remove, inactivate, or destroy bloodborne pathogens on a surface or item to the point where they are no longer capable of transmitting infectious particles and

the surface or item is rendered safe for handling, use, or disposal.

Director means the Director of the National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designated representative.

Engineering controls means controls (e.g., sharps disposal containers, self-sheathing needles, safer medical devices, such as sharps with engineered sharps injury protections and needleless systems) that isolate or remove the bloodborne pathogens hazard from the workplace.

Exposure Incident means a specific eye, mouth, other mucous membrane, non-intact skin, or parenteral contact with blood or other potentially infectious materials that results from the performance of an employee's duties.

Handwashing Facilities means a facility providing an adequate supply of running potable water, soap and single use towels or hot air drying machines.

Licensed Healthcare Professional is a person whose legally permitted scope of practice allows him or her to independently perform the activities required by paragraph (f) Hepatitis B Vaccination and Post-exposure Evaluation and Follow-up.

HBV means hepatitis B virus.

HIV means human immunodeficiency virus.

Needleless systems means a device that does not use needles for:

(1) The collection of bodily fluids or withdrawal of body fluids after initial venous or arterial access is established;

(2) The administration of medication or fluids; or

(3) Any other procedure involving the potential for occupational exposure to bloodborne pathogens due to percutaneous injuries from contaminated sharps.

Occupational Exposure means reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duties.

Other Potentially Infectious Materials means

(1) The following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids;

(2) Any unfixed tissue or organ (other than intact skin) from a human (living or dead); and

(3) HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.

Parenteral means piercing mucous membranes or the skin barrier through such events as needlesticks, human bites, cuts, and abrasions.

Personal Protective Equipment is specialized clothing or equipment worn by an employee for protection against a hazard. General work clothes (e.g., uniforms, pants, shirts or blouses) not intended to function as protection against a hazard are not considered to be personal protective equipment.

Production Facility means a facility engaged in industrial-scale, large-volume or high concentration production of HIV or HBV.

Regulated Waste means liquid or semi-liquid blood or other potentially infectious materials; contaminated items that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed; items that are caked with dried blood or other potentially infectious materials and are capable of releasing these materials during handling; contaminated sharps; and pathological and microbiological wastes containing blood or other potentially infectious materials.

Research Laboratory means a laboratory producing or using research-laboratory-scale amounts of HIV or HBV. Research laboratories may produce high concentrations of HIV or HBV but not in the volume found in production facilities.

Sharps with engineered sharps injury protections means a nonneedle sharp or a needle device used for withdrawing body fluids, accessing a vein or artery, or administering medications or other fluids, with a built-in safety feature or

mechanism that effectively reduces the risk of an exposure incident.

Source Individual means any individual, living or dead, whose blood or other potentially infectious materials may be a source of occupational exposure to the employee. Examples include, but are not limited to, hospital and clinic patients; clients in institutions for the developmentally disabled; trauma victims; clients of drug and alcohol treatment facilities; residents of hospices and nursing homes; human remains; and individuals who donate or sell blood or blood components.

Sterilize means the use of a physical or chemical procedure to destroy all microbial life including highly resistant bacterial endospores.

Universal Precautions is an approach to infection control. According to the concept of Universal Precautions, all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens.

Work Practice Controls means controls that reduce the likelihood of exposure by altering the manner in which a task is performed (e.g., prohibiting recapping of needles by a two-handed technique).

(c) *Exposure control*—(1) *Exposure Control Plan.* (i) Each employer having an employee(s) with occupational exposure as defined by paragraph (b) of this section shall establish a written Exposure Control Plan designed to eliminate or minimize employee exposure.

(ii) The Exposure Control Plan shall contain at least the following elements:

(A) The exposure determination required by paragraph(c)(2),

(B) The schedule and method of implementation for paragraphs (d) Methods of Compliance, (e) HIV and HBV Research Laboratories and Production Facilities, (f) Hepatitis B Vaccination and Post-Exposure Evaluation and Follow-up, (g) Communication of Hazards to Employees, and (h) Recordkeeping, of this standard, and

(C) The procedure for the evaluation of circumstances surrounding exposure incidents as required by paragraph (f)(3)(i) of this standard.

(iii) Each employer shall ensure that a copy of the Exposure Control Plan is accessible to employees in accordance with 29 CFR 1910.20(e).

(iv) The Exposure Control Plan shall be reviewed and updated at least annually and whenever necessary to reflect new or modified tasks and procedures which affect occupational exposure and to reflect new or revised employee positions with occupational exposure. The review and update of such plans shall also:

(A) Reflect changes in technology that eliminate or reduce exposure to bloodborne pathogens; and

(B) Document annually consideration and implementation of appropriate commercially available and effective safer medical devices designed to eliminate or minimize occupational exposure.

(v) An employer, who is required to establish an Exposure Control Plan shall solicit input from non-managerial employees responsible for direct patient care who are potentially exposed to injuries from contaminated sharps in the identification, evaluation, and selection of effective engineering and work practice controls and shall document the solicitation in the Exposure Control Plan.

(vi) The Exposure Control Plan shall be made available to the Assistant Secretary and the Director upon request for examination and copying.

(2) *Exposure determination.* (i) Each employer who has an employee(s) with occupational exposure as defined by paragraph (b) of this section shall prepare an exposure determination. This exposure determination shall contain the following:

(A) A list of all job classifications in which all employees in those job classifications have occupational exposure;

(B) A list of job classifications in which some employees have occupational exposure, and

(C) A list of all tasks and procedures or groups of closely related task and procedures in which occupational exposure occurs and that are performed by employees in job classifications listed in accordance with the provisions of paragraph (c)(2)(i)(B) of this standard.

(ii) This exposure determination shall be made without regard to the use of personal protective equipment.

(d) *Methods of compliance*—(1) *General.* Universal precautions shall be observed to prevent contact with blood or other potentially infectious materials. Under circumstances in which differentiation between body fluid types is difficult or impossible, all body fluids shall be considered potentially infectious materials.

(2) *Engineering and work practice controls.* (i) Engineering and work practice controls shall be used to eliminate or minimize employee exposure. Where occupational exposure remains after institution of these controls, personal protective equipment shall also be used.

(ii) Engineering controls shall be examined and maintained or replaced on a regular schedule to ensure their effectiveness.

(iii) Employers shall provide handwashing facilities which are readily accessible to employees.

(iv) When provision of handwashing facilities is not feasible, the employer shall provide either an appropriate antiseptic hand cleanser in conjunction with clean cloth/paper towels or antiseptic towelettes. When antiseptic hand cleansers or towelettes are used, hands shall be washed with soap and running water as soon as feasible.

(v) Employers shall ensure that employees wash their hands immediately or as soon as feasible after removal of gloves or other personal protective equipment.

(vi) Employers shall ensure that employees wash hands and any other skin with soap and water, or flush mucous membranes with water immediately or as soon as feasible following contact of such body areas with blood or other potentially infectious materials.

(vii) Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed except as noted in paragraphs (d)(2)(vii)(A) and (d)(2)(vii)(B) below. Shearing or breaking of contaminated needles is prohibited.

(A) Contaminated needles and other contaminated sharps shall not be bent, recapped or removed unless the employer can demonstrate that no alternative is feasible or that such action is required by a specific medical or dental procedure.

(B) Such bending, recapping or needle removal must be accomplished through the use of a mechanical device or a one-handed technique.

(viii) Immediately or as soon as possible after use, contaminated reusable sharps shall be placed in appropriate containers until properly reprocessed. These containers shall be:

(A) Puncture resistant;

(B) Labeled or color-coded in accordance with this standard;

(C) Leakproof on the sides and bottom; and

(D) In accordance with the requirements set forth in paragraph (d)(4)(ii)(E) for reusable sharps.

(ix) Eating, drinking, smoking, applying cosmetics or lip balm, and handling contact lenses are prohibited in work areas where there is a reasonable likelihood of occupational exposure.

(x) Food and drink shall not be kept in refrigerators, freezers, shelves, cabinets or on countertops or benchtops where blood or other potentially infectious materials are present.

(xi) All procedures involving blood or other potentially infectious materials shall be performed in such a manner as to minimize splashing, spraying, spattering, and generation of droplets of these substances.

(xii) Mouth pipetting/suctioning of blood or other potentially infectious materials is prohibited.

(xiii) Specimens of blood or other potentially infectious materials shall be placed in a container which prevents leakage during collection, handling, processing, storage, transport, or shipping.

(A) The container for storage, transport, or shipping shall be labeled or color-coded according to paragraph (g)(1)(i) and closed prior to being stored, transported, or shipped. When a facility utilizes Universal Precautions in the handling of all specimens, the labeling/color-coding of specimens is not necessary provided containers are recognizable as containing specimens. This exemption only applies while such specimens/containers remain within the facility. Labeling or color-coding in accordance with paragraph (g)(1)(i) is required when such specimens/containers leave the facility.

(B) If outside contamination of the primary container occurs, the primary container shall be placed within a second container which prevents leakage during handling, processing, storage, transport, or shipping and is labeled or color-coded according to the requirements of this standard.

(C) If the specimen could puncture the primary container, the primary container shall be placed within a secondary container which is puncture-resistant in addition to the above characteristics.

(xiv) Equipment which may become contaminated with blood or other potentially infectious materials shall be examined prior to servicing or shipping and shall be decontaminated as necessary, unless the employer can demonstrate that decontamination of such equipment or portions of such equipment is not feasible.

(A) A readily observable label in accordance with paragraph (g)(1)(i)(H) shall be attached to the equipment stating which portions remain contaminated.

(B) The employer shall ensure that this information is conveyed to all affected employees, the servicing representative, and/or the manufacturer, as appropriate, prior to handling, servicing, or shipping so that appropriate precautions will be taken.

(3) *Personal protective equipment*—(i) *Provision.* When there is occupational exposure, the employer shall provide, at no cost to the employee, appropriate personal protective equipment such as, but not limited to, gloves, gowns, laboratory coats, face shields or masks and eye protection, and mouthpieces, resuscitation bags, pocket masks, or other ventilation devices. Personal protective equipment will be considered "appropriate" only if it does not permit blood or other potentially infectious materials to pass through to or reach the employee's work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time which the protective equipment will be used.

(ii) *Use.* The employer shall ensure that the employee uses appropriate personal protective equipment unless the employer shows that the employee temporarily and briefly declined to use personal protective equipment when, under rare and extraordinary circumstances, it was the employee's professional judgment that in the specific instance its use would have prevented the delivery of health care or public safety services or would have posed an increased hazard to the safety of the worker or co-worker. When the employee makes this judgement, the circumstances shall be investigated and documented in order to determine whether changes can be instituted to prevent such occurences in the future.

(iii) *Accessibility.* The employer shall ensure that appropriate personal protective equipment in the appropriate sizes is readily accessible at the worksite or is issued to employees. Hypoallergenic gloves, glove liners, powderless gloves, or other similar alternatives shall be readily accessible to those employees who are allergic to the gloves normally provided.

(iv) *Cleaning, Laundering, and Disposal.* The employer shall clean, launder, and dispose of personal protective equipment required by paragraphs (d) and (e) of this standard, at no cost to the employee.

(v) *Repair and Replacement.* The employer shall repair or replace personal protective equipment as needed to maintain its effectiveness, at no cost to the employee.

(vi) If a garment(s) is penetrated by blood or other potentially infectious materials, the garment(s) shall be removed immediately or as soon as feasible.

(vii) All personal protective equipment shall be removed prior to leaving the work area.

(viii) When personal protective equipment is removed it shall be placed in an appropriately designated area or container for storage, washing, decontamination or disposal.

(ix) *Gloves.* Gloves shall be worn when it can be reasonably anticipated that the employee may have hand contact with blood, other potentially infectious materials, mucous membranes, and non-intact skin; when performing vascular access procedures except as specified in paragraph (d)(3)(ix)(D); and when handling or touching contaminated items or surfaces.

(A) Disposable (single use) gloves such as surgical or examination gloves, shall be replaced as soon as practical when contaminated or as soon as feasible if they are torn, punctured, or when their ability to function as a barrier is compromised.

(B) Disposable (single use) gloves shall not be washed or decontaminated for re-use.

(C) Utility gloves may be decontaminated for re-use if the integrity of the glove is not compromised. However, they must be discarded if they are cracked, peeling, torn, punctured, or exhibit other signs of deterioration or when their ability to function as a barrier is compromised.

(D) If an employer in a volunteer blood donation center judges that routine gloving for all phlebotomies is not necessary then the employer shall:

(*1*) Periodically reevaluate this policy;

(*2*) Make gloves available to all employees who wish to use them for phlebotomy;

(*3*) Not discourage the use of gloves for phlebotomy; and

(*4*) Require that gloves be used for phlebotomy in the following circumstances:

(*i*) When the employee has cuts, scratches, or other breaks in his or her skin;

(*ii*) When the employee judges that hand contamination with blood may occur, for example, when performing phlebotomy on an uncooperative source individual; and

(*iii*) When the employee is receiving training in phlebotomy.

(x) *Masks, Eye Protection, and Face Shields.* Masks in combination with eye protection devices, such as goggles or glasses with solid side shields, or chin-length face shields, shall be worn whenever splashes, spray, spatter, or droplets of blood or other potentially infectious materials may be generated and eye, nose, or mouth contamination can be reasonably anticipated.

(xi) *Gowns, Aprons, and Other Protective Body Clothing.* Appropriate protective clothing such as, but not limited to, gowns, aprons, lab coats, clinic jackets, or similar outer garments shall be worn in occupational exposure situations. The type and characteristics will depend upon the task and degree of exposure anticipated.

(xii) Surgical caps or hoods and/or shoe covers or boots shall be worn in instances when gross contamination can reasonably be anticipated (e.g., autopsies, orthopaedic surgery).

(4) *Housekeeping*—(i) *General.* Employers shall ensure that the worksite is maintained in a clean and sanitary condition. The employer shall determine and implement an appropriate written schedule for cleaning and method of decontamination based upon the location within the facility, type of surface to be cleaned, type of soil present, and tasks or procedures being performed in the area.

(ii) All equipment and environmental and working surfaces shall be cleaned and decontaminated after contact with blood or other potentially infectious materials.

(A) Contaminated work surfaces shall be decontaminated with an appropriate disinfectant after completion of procedures; immediately or as soon as feasible when surfaces are overtly contaminated or after any spill of blood or other potentially infectious materials; and at the end of the work shift if the surface may have become contaminated since the last cleaning.

(B) Protective coverings, such as plastic wrap, aluminum foil, or imperviously-backed absorbent paper used to cover equipment and environmental surfaces, shall be removed and replaced as soon as feasible when they become overtly contaminated or at the end of the workshift if they may have become contaminated during the shift.

(C) All bins, pails, cans, and similar receptacles intended for reuse which have a reasonable likelihood for becoming contaminated with blood or other potentially infectious materials shall be inspected and decontaminated on a regularly scheduled basis and cleaned and decontaminated immediately or as soon as feasible upon visible contamination.

(D) Broken glassware which may be contaminated shall not be picked up directly with the hands. It shall be cleaned up using mechanical means, such as a brush and dust pan, tongs, or forceps.

(E) Reusable sharps that are contaminated with blood or other potentially infectious materials shall not be stored or processed in a manner that requires employees to reach by hand into the containers where these sharps have been placed.

(iii) *Regulated Waste*—(A) *Contaminated Sharps Discarding and Containment.* (*1*) Contaminated sharps shall be discarded immediately or as soon as feasible in containers that are:

(*i*) Closable;

(*ii*) Puncture resistant;

(*iii*) Leakproof on sides and bottom; and

(*iv*) Labeled or color-coded in accordance with paragraph (g)(1)(i) of this standard.

(*2*) During use, containers for contaminated sharps shall be:

(*i*) Easily accessible to personnel and located as close as is feasible to the immediate area where sharps are used or can be reasonably anticipated to be found (e.g., laundries);

(*ii*) Maintained upright throughout use; and

(*iii*) Replaced routinely and not be allowed to overfill.

(*3*) When moving containers of contaminated sharps from the area of use, the containers shall be:

(*i*) Closed immediately prior to removal or replacement to prevent spillage or protrusion of contents during handling, storage, transport, or shipping;

(*ii*) Placed in a secondary container if leakage is possible. The second container shall be:

(*A*) Closable;

(*B*) Constructed to contain all contents and prevent leakage during handling, storage, transport, or shipping; and

(*C*) Labeled or color-coded according to paragraph (g)(1)(i) of this standard.

(*4*) Reusable containers shall not be opened, emptied, or cleaned manually or in any other manner which would expose employees to the risk of percutaneous injury.

(B) *Other Regulated Waste Containment*—(*1*) Regulated waste shall be placed in containers which are:

(*i*) Closable;

(*ii*) Constructed to contain all contents and prevent leakage of fluids during handling, storage, transport or shipping;

(*iii*) Labeled or color-coded in accordance with paragraph (g)(1)(i) this standard; and

(*iv*) Closed prior to removal to prevent spillage or protrusion of contents during handling, storage, transport, or shipping.

(*2*) If outside contamination of the regulated waste container occurs, it shall be placed in a second container. The second container shall be:

(*i*) Closable;

(*ii*) Constructed to contain all contents and prevent leakage of fluids during handling, storage, transport or shipping;

(*iii*) Labeled or color-coded in accordance with paragraph (g)(1)(i) of this standard; and

(*iv*) Closed prior to removal to prevent spillage or protrusion of contents during handling, storage, transport, or shipping.

(C) Disposal of all regulated waste shall be in accordance with applicable regulations of the United States, States and Territories, and political subdivisions of States and Territories.

(iv) *Laundry.* (A) Contaminated laundry shall be handled as little as possible with a minimum of agitation. (1) Contaminated laundry shall be bagged or containerized at the location where it was used and shall not be sorted or rinsed in the location of use.

(2) Contaminated laundry shall be placed and transported in bags or containers labeled or color-coded in accordance with paragraph (g)(1)(i) of this standard. When a facility utilizes Universal Precautions in the handling of all soiled laundry, alternative labeling or color-coding is sufficient if it permits all employees to recognize the containers as requiring compliance with Universal Precautions.

(3) Whenever contaminated laundry is wet and presents a reasonable likelihood of soak-through of or leakage from the bag or container, the laundry shall be placed and transported in bags or containers which prevent soak-through and/or leakage of fluids to the exterior.

(B) The employer shall ensure that employees who have contact with contaminated laundry wear protective

gloves and other appropriate personal protective equipment.

(C) When a facility ships contaminated laundry off-site to a second facility which does not utilize Universal Precautions in the handling of all laundry, the facility generating the contaminated laundry must place such laundry in bags or containers which are labeled or color-coded in accordance with paragraph (g)(1)(i).

(e) *HIV and HBV Research Laboratories and Production Facilities.* (1) This paragraph applies to research laboratories and production facilities engaged in the culture, production, concentration, experimentation, and manipulation of HIV and HBV. It does not apply to clinical or diagnostic laboratories engaged solely in the analysis of blood, tissues, or organs. These requirements apply in addition to the other requirements of the standard.

(2) Research laboratories and production facilities shall meet the following criteria:

(i) *Standard microbiological practices.* All regulated waste shall either be incinerated or decontaminated by a method such as autoclaving known to effectively destroy bloodborne pathogens.

(ii) *Special practices.* (A) Laboratory doors shall be kept closed when work involving HIV or HBV is in progress.

(B) Contaminated materials that are to be decontaminated at a site away from the work area shall be placed in a durable, leakproof, labeled or color-coded container that is closed before being removed from the work area.

(C) Access to the work area shall be limited to authorized persons. Written policies and procedures shall be established whereby only persons who have been advised of the potential biohazard, who meet any specific entry requirements, and who comply with all entry and exit procedures shall be allowed to enter the work areas and animal rooms.

(D) When other potentially infectious materials or infected animals are present in the work area or containment module, a hazard warning sign incorporating the universal biohazard symbol shall be posted on all access doors. The hazard warning sign shall comply with paragraph (g)(1)(ii) of this standard.

(E) All activities involving other potentially infectious materials shall be conducted in biological safety cabinets or other physical-containment devices within the containment module. No work with these other potentially infectious materials shall be conducted on the open bench.

(F) Laboratory coats, gowns, smocks, uniforms, or other appropriate protective clothing shall be used in the work area and animal rooms. Protective clothing shall not be worn outside of the work area and shall be decontaminated before being laundered.

(G) Special care shall be taken to avoid skin contact with other potentially infectious materials. Gloves shall be worn when handling infected animals and when making hand contact with other potentially infectious materials is unavoidable.

(H) Before disposal all waste from work areas and from animal rooms shall either be incinerated or decontaminated by a method such as autoclaving known to effectively destroy bloodborne pathogens.

(I) Vacuum lines shall be protected with liquid disinfectant traps and high-efficiency particulate air (HEPA) filters or filters of equivalent or superior efficiency and which are checked routinely and maintained or replaced as necessary.

(J) Hypodermic needles and syringes shall be used only for parenteral injection and aspiration of fluids from laboratory animals and diaphragm bottles. Only needle-locking syringes or disposable syringe-needle units (i.e., the needle is integral to the syringe) shall be used for the injection or aspiration of other potentially infectious materials. Extreme caution shall be used when handling needles and syringes. A needle shall not be bent, sheared, replaced in the sheath or guard, or removed from the syringe following use. The needle and syringe shall be promptly placed in a puncture-resistant container and autoclaved or decontaminated before reuse or disposal.

(K) All spills shall be immediately contained and cleaned up by appropriate professional staff or others properly trained and equipped to work with potentially concentrated infectious materials.

(L) A spill or accident that results in an exposure incident shall be immediately reported to the laboratory director or other responsible person.

(M) A biosafety manual shall be prepared or adopted and periodically reviewed and updated at least annually or more often if necessary. Personnel shall be advised of potential hazards, shall be required to read instructions on practices and procedures, and shall be required to follow them.

(iii) *Containment equipment.* (A) Certified biological safety cabinets (Class I, II, or III) or other appropriate combinations of personal protection or physical containment devices, such as special protective clothing, respirators, centrifuge safety cups, sealed centrifuge rotors, and containment caging for animals, shall be used for all activities with other potentially infectious materials that pose a threat of exposure to droplets, splashes, spills, or aerosols.

(B) Biological safety cabinets shall be certified when installed, whenever they are moved and at least annually.

(3) HIV and HBV research laboratories shall meet the following criteria:

(i) Each laboratory shall contain a facility for hand washing and an eye wash facility which is readily available within the work area.

(ii) An autoclave for decontamination of regulated waste shall be available.

(4) HIV and HBV production facilities shall meet the following criteria:

(i) The work areas shall be separated from areas that are open to unrestricted traffic flow within the building. Passage through two sets of doors shall be the basic requirement for entry into the work area from access corridors or other contiguous areas. Physical separation of the high-containment work area from access corridors or other areas or activities may also be provided by a double-doored clothes-change room (showers may be included), airlock, or other access facility that requires passing through two sets of doors before entering the work area.

(ii) The surfaces of doors, walls, floors and ceilings in the work area shall be water resistant so that they can be easily cleaned. Penetrations in these surfaces shall be sealed or capable of being sealed to facilitate decontamination.

(iii) Each work area shall contain a sink for washing hands and a readily available eye wash facility. The sink shall be foot, elbow, or automatically operated and shall be located near the exit door of the work area.

(iv) Access doors to the work area or containment module shall be self-closing.

(v) An autoclave for decontamination of regulated waste shall be available within or as near as possible to the work area.

(vi) A ducted exhaust-air ventilation system shall be provided. This system shall create directional airflow that draws air into the work area through the entry area. The exhaust air shall not be recirculated to any other area of the building, shall be discharged to the outside, and shall be dispersed away from occupied areas and air intakes. The proper direction of the airflow shall be verified (i.e., into the work area).

(5) *Training Requirements.* Additional training requirements for employees in HIV and HBV research laboratories and HIV and HBV production facilities are specified in paragraph (g)(2)(ix).

(f) *Hepatitis B vaccination and post-exposure evaluation and follow-up*—(1) *General.* (i) The employer shall make available the hepatitis B vaccine and vaccination series to all employees who have occupational exposure, and post-exposure evaluation and follow-up to all employees who have had an exposure incident.

(ii) The employer shall ensure that all medical evaluations and procedures including the hepatitis B vaccine and vaccination series and post-exposure evaluation and follow-up, including prophylaxis, are:

(A) Made available at no cost to the employee;

(B) Made available to the employee at a reasonable time and place;

(C) Performed by or under the supervision of a licensed physician or by or under the supervision of another licensed healthcare professional; and

(D) Provided according to recommendations of the U.S. Public Health Service current at the time these evaluations and procedures take place, except as specified by this paragraph (f).

(iii) The employer shall ensure that all laboratory tests are conducted by an accredited laboratory at no cost to the employee.

(2) *Hepatitis B Vaccination.* (i) Hepatitis B vaccination shall be made available after the employee has received the training required in paragraph (g)(2)(vii)(I) and within 10 working days of initial assignment to all employees who have occupational exposure unless the employee has previously received the complete hepatitis B vaccination series, antibody testing has revealed that the employee is immune, or the vaccine is contraindicated for medical reasons.

(ii) The employer shall not make participation in a prescreening program a prerequisite for receiving hepatitis B vaccination.

(iii) If the employee initially declines hepatitis B vaccination but at a later date while still covered under the standard decides to accept the vaccination, the employer shall make available hepatitis B vaccination at that time.

(iv) The employer shall assure that employees who decline to accept hepatitis B vaccination offered by the employer sign the statement in appendix A.

(v) If a routine booster dose(s) of hepatitis B vaccine is recommended by the U.S. Public Health Service at a future date, such booster dose(s) shall be made available in accordance with section (f)(1)(ii).

(3) *Post-exposure Evaluation and Follow-up.* Following a report of an exposure incident, the employer shall make immediately available to the exposed employee a confidential medical evaluation and follow-up, including at least the following elements:

(i) Documentation of the route(s) of exposure, and the circumstances under which the exposure incident occurred;

(ii) Identification and documentation of the source individual, unless the employer can establish that identification is infeasible or prohibited by state or local law;

(A) The source individual's blood shall be tested as soon as feasible and after consent is obtained in order to determine HBV and HIV infectivity. If consent is not obtained, the employer shall establish that legally required consent cannot be obtained. When the source individual's consent is not required by law, the source individual's blood, if available, shall be tested and the results documented.

(B) When the source individual is already known to be infected with HBV or HIV, testing for the source individual's known HBV or HIV status need not be repeated.

(C) Results of the source individual's testing shall be made available to the exposed employee, and the employee shall be informed of applicable laws and regulations concerning disclosure of the identity and infectious status of the source individual.

(iii) Collection and testing of blood for HBV and HIV serological status;

(A) The exposed employee's blood shall be collected as soon as feasible and tested after consent is obtained.

(B) If the employee consents to baseline blood collection, but does not give consent at that time for HIV serologic testing, the sample shall be preserved for at least 90 days. If, within 90 days of the exposure incident, the employee elects to have the baseline sample tested, such testing shall be done as soon as feasible.

(iv) Post-exposure prophylaxis, when medically indicated, as recommended by the U.S. Public Health Service;

(v) Counseling; and

(vi) Evaluation of reported illnesses.

(4) *Information Provided to the Healthcare Professional.* (i) The employer shall ensure that the healthcare professional responsible for the employee's Hepatitis B vaccination is provided a copy of this regulation.

(ii) The employer shall ensure that the healthcare professional evaluating an employee after an exposure incident is provided the following information:

(A) A copy of this regulation;

(B) A description of the exposed employee's duties as they relate to the exposure incident;

(C) Documentation of the route(s) of exposure and circumstances under which exposure occurred;

(D) Results of the source individual's blood testing, if available; and

(E) All medical records relevant to the appropriate treatment of the employee including vaccination status which are the employer's responsibility to maintain.

(5) *Healthcare Professional's Written Opinion.* The employer shall obtain and provide the employee with a copy of the evaluating healthcare professional's written opinion within 15 days of the completion of the evaluation.

(i) The healthcare professional's written opinion for Hepatitis B vaccination shall be limited to whether Hepatitis B vaccination is indicated for an employee, and if the employee has received such vaccination.

(ii) The healthcare professional's written opinion for post-exposure evaluation and follow-up shall be limited to the following information:

(A) That the employee has been informed of the results of the evaluation; and

(B) That the employee has been told about any medical conditions resulting from exposure to blood or other potentially infectious materials which require further evaluation or treatment.

(iii) All other findings or diagnoses shall remain confidential and shall not be included in the written report.

(6) *Medical recordkeeping.* Medical records required by this standard shall be maintained in accordance with paragraph (h)(1) of this section.

(g) *Communication of hazards to employees*—(1) *Labels and signs*—(i) *Labels.* (A) Warning labels shall be affixed to containers of regulated waste, refrigerators and freezers containing blood or other potentially infectious material; and other containers used to store, transport or ship blood or other potentially infectious materials, except as provided in paragraph (g)(1)(i)(E), (F) and (G).

(B) Labels required by this section shall include the following legend:

BIOHAZARD

(C) These labels shall be fluorescent orange or orange-red or predominantly so, with lettering and symbols in a contrasting color.

(D) Labels shall be affixed as close as feasible to the container by string, wire, adhesive, or other method that prevents their loss or unintentional removal.

(E) Red bags or red containers may be substituted for labels.

(F) Containers of blood, blood components, or blood products that are labeled as to their contents and have been released for transfusion or other clinical use are exempted from the labeling requirements of paragraph (g).

(G) Individual containers of blood or other potentially infectious materials that are placed in a labeled container during storage, transport, shipment or disposal are exempted from the labeling requirement.

(H) Labels required for contaminated equipment shall be in accordance with this paragraph and shall also state which portions of the equipment remain contaminated.

(I) Regulated waste that has been decontaminated need not be labeled or color-coded.

(ii) *Signs.* (A) The employer shall post signs at the entrance to work areas specified in paragraph (e), HIV and HBV Research Laboratory and Production Facilities, which shall bear the following legend:

BIOHAZARD

(Name of the Infectious Agent)
(Special requirements for entering the area)
(Name, telephone number of the laboratory director or other responsible person.)

(B) These signs shall be fluorescent orange-red or predominantly so, with lettering and symbols in a contrasting color.

(2) *Information and Training.* (i) Employers shall ensure that all employees with occupational exposure participate in a training program which must be provided at no cost to the employee and during working hours.

(ii) Training shall be provided as follows:

(A) At the time of initial assignment to tasks where occupational exposure may take place;

(B) Within 90 days after the effective date of the standard; and

(C) At least annually thereafter.

(iii) For employees who have received training on bloodborne pathogens in the year preceding the effective date of the standard, only training with respect to the provisions of the standard which were not included need be provided.

(iv) Annual training for all employees shall be provided within one year of their previous training.

(v) Employers shall provide additional training when changes such as modification of tasks or procedures or institution of new tasks or procedures affect the employee's occupational exposure. The additional training may be limited to addressing the new exposures created.

(vi) Material appropriate in content and vocabulary to educational level, literacy, and language of employees shall be used.

(vii) The training program shall contain at a minimum the following elements:

(A) An accessible copy of the regulatory text of this standard and an explanation of its contents;

(B) A general explanation of the epidemiology and symptoms of bloodborne diseases;

(C) An explanation of the modes of transmission of bloodborne pathogens;

(D) An explanation of the employer's exposure control plan and the means by which the employee can obtain a copy of the written plan;

(E) An explanation of the appropriate methods for recognizing tasks and other activities that may involve exposure to blood and other potentially infectious materials;

(F) An explanation of the use and limitations of methods that will prevent or reduce exposure including appropriate engineering controls, work practices, and personal protective equipment;

(G) Information on the types, proper use, location, removal, handling, decontamination and disposal of personal protective equipment;

(H) An explanation of the basis for selection of personal protective equipment;

(I) Information on the hepatitis B vaccine, including information on its efficacy, safety, method of administration, the benefits of being vaccinated, and that the vaccine and vaccination will be offered free of charge;

(J) Information on the appropriate actions to take and persons to contact in an emergency involving blood or other potentially infectious materials;

(K) An explanation of the procedure to follow if an exposure incident occurs, including the method of reporting the incident and the medical follow-up that will be made available;

(L) Information on the post-exposure evaluation and follow-up that the employer is required to provide for the employee following an exposure incident;

(M) An explanation of the signs and labels and/or color coding required by paragraph (g)(1); and

(N) An opportunity for interactive questions and answers with the person conducting the training session.

(viii) The person conducting the training shall be knowledgeable in the subject matter covered by the elements

contained in the training program as it relates to the workplace that the training will address.

(ix) Additional Initial Training for Employees in HIV and HBV Laboratories and Production Facilities. Employees in HIV or HBV research laboratories and HIV or HBV production facilities shall receive the following initial training in addition to the above training requirements.

(A) The employer shall assure that employees demonstrate proficiency in standard microbiological practices and techniques and in the practices and operations specific to the facility before being allowed to work with HIV or HBV.

(B) The employer shall assure that employees have prior experience in the handling of human pathogens or tissue cultures before working with HIV or HBV.

(C) The employer shall provide a training program to employees who have no prior experience in handling human pathogens. Initial work activities shall not include the handling of infectious agents. A progression of work activities shall be assigned as techniques are learned and proficiency is developed. The employer shall assure that employees participate in work activities involving infectious agents only after proficiency has been demonstrated.

(h) *Recordkeeping*—(1) *Medical Records.* (i) The employer shall establish and maintain an accurate record for each employee with occupational exposure, in accordance with 29 CFR 1910.20.

(ii) This record shall include:

(A) The name and social security number of the employee;

(B) A copy of the employee's hepatitis B vaccination status including the dates of all the hepatitis B vaccinations and any medical records relative to the employee's ability to receive vaccination as required by paragraph (f)(2);

(C) A copy of all results of examinations, medical testing, and follow-up procedures as required by paragraph (f)(3);

(D) The employer's copy of the healthcare professional's written opinion as required by paragraph (f)(5); and

(E) A copy of the information provided to the healthcare professional as required by paragraphs (f)(4)(ii)(B)(C) and (D).

(iii) Confidentiality. The employer shall ensure that employee medical records required by paragraph (h)(1) are:

(A) Kept confidential; and

(B) Not disclosed or reported without the employee's express written consent to any person within or outside the workplace except as required by this section or as may be required by law.

(iv) The employer shall maintain the records required by paragraph (h) for at least the duration of employment plus 30 years in accordance with 29 CFR 1910.20.

(2) *Training Records.* (i) Training records shall include the following information:

(A) The dates of the training sessions;

(B) The contents or a summary of the training sessions;

(C) The names and qualifications of persons conducting the training; and

(D) The names and job titles of all persons attending the training sessions.

(ii) Training records shall be maintained for 3 years from the date on which the training occurred.

(3) *Availability.* (i) The employer shall ensure that all records required to be maintained by this section shall be made available upon request to the Assistant Secretary and the Director for examination and copying.

(ii) Employee training records required by this paragraph shall be provided upon request for examination and copying to employees, to employee representatives, to the Director, and to the Assistant Secretary.

(iii) Employee medical records required by this paragraph shall be provided upon request for examination and copying to the subject employee, to anyone having written consent of the subject employee, to the Director, and to the Assistant Secretary in accordance with 29 CFR 1910.20.

(4) *Transfer of Records.* (i) The employer shall comply with the requirements involving transfer of records set forth in 29 CFR 1910.20(h).

(ii) If the employer ceases to do business and there is no successor employer to receive and retain the records for the prescribed period, the employer shall notify the Director, at least three months prior to their disposal and transmit them to the Director, if required by the Director to do so, within that three month period.

(i) *Dates*—(1) *Effective Date.* The standard shall become effective on March 6, 1992.

(2) The Exposure Control Plan required by paragraph (c) of this section shall be completed on or before May 5, 1992.

(3) Paragraph (g)(2) Information and Training and (h) Recordkeeping shall take effect on or before June 4, 1992.

(4) Paragraphs (d)(2) Engineering and Work Practice Controls, (d)(3) Personal Protective Equipment, (d)(4) Housekeeping, (e) HIV and HBV Research Laboratories and Production Facilities, (f) Hepatitis B Vaccination and Post-Exposure Evaluation and Follow-up, and (g) (1) Labels and Signs, shall take effect July 6, 1992.

(5) *Sharps injury log.* (i) The employer shall establish and maintain a sharps injury log for the recording of percutaneous injuries from contaminated sharps. The information in the sharps injury log shall be recorded and maintained in such manner as to protect the confidentiality of the injured employee. The sharps injury log shall contain, at a minimum:

(A) The type and brand of device involved in the incident,

(B) The department or work area where the exposure incident occurred, and

(C) An explanation of how the incident occurred.

(ii) The requirement to establish and maintain a sharps injury log shall apply to any employer who is required to maintain a log of occupational injuries and illnesses under 29 CFR 1904.

(iii) The sharps injury log shall be maintained for the period required by 29 CFR 1904.6.

APPENDIX A TO SECTION 1910.1030—HEPATITIS B VACCINE DECLINATION (MANDATORY)

I understand that due to my occupational exposure to blood or other potentially infectious materials I may be at risk of acquiring hepatitis B virus (HBV) infection. I have been given the opportunity to be vaccinated with hepatitis B vaccine, at no charge to myself. However, I decline hepatitis B vaccination at this time. I understand that by declining this vaccine, I continue to be at risk of acquiring hepatitis B, a serious disease. If in the future I continue to have occupational exposure to blood or other potentially infectious materials and I want to be vaccinated with hepatitis B vaccine, I can receive the vaccination series at no charge to me.

[56 FR 64175, Dec. 6, 1991, as amended at 57 FR 12717, Apr. 13, 1992; 57 FR 29206, July 1, 1992; 61 FR 5508, Feb. 13, 1996; 66 FR 5325, Jan. 18, 2001]

§ 1910.1043 Cotton dust.

(a) *Scope and application.* (1) This section, in its entirety, applies to the control of employee exposure to cotton dust in all workplaces where employees engage in yarn manufacturing, engage in slashing and weaving operations, or work in waste houses for textile operations.

(2) This section does not apply to the handling or processing of woven or knitted materials; to maritime operations covered by 29 CFR Parts 1915 and 1918; to harvesting or ginning of cotton; or to the construction industry.

(3) Only paragraphs (h) Medical surveillance, (k)(2) through (4) Recordkeeping—Medical Records, and Appendices B, C and D of this section apply in all work places where employees exposed to cotton dust engage in cottonseed processing or waste processing operations.

(4) This section applies to yarn manufacturing and slashing and weaving operations exclusively using washed cotton (as defined by paragraph (n) of this section) only to the extent specified by paragraph (n) of this section.

(5) This section, in its entirety, applies to the control of all employees exposure to the cotton dust generated in the preparation of washed cotton from opening until the cotton is thoroughly wetted.

(6) This section does not apply to knitting, classing or warehousing operations except that employers with these operations, if requested by NIOSH, shall grant NIOSH access to their employees and workplaces for exposure monitoring and medical examinations for purposes of a health study